United States Patent

Berndt

[11] 3,736,411
[45] May 29, 1973

[54] **GRAPHICS DISPLAY SYSTEM**

[75] Inventor: **Carl W. Berndt**, Danville, Calif.

[73] Assignee: **The United States of America as represented by the Atomic Energy Commission**, Washington, D.C.

[22] Filed: **May 17, 1971**

[21] Appl. No.: **144,035**

Related U.S. Application Data

[63] Continuation-in-part of Ser. No. 816,349, April 15, 1969, abandoned.

[52] **U.S. Cl.** ....**235/151**, 35/25, 353/31, 353/11, 340/324 A, 444/1

[51] **Int. Cl.** **G03b 29/00**

[58] **Field of Search** 235/151

[56] **References Cited**

UNITED STATES PATENTS

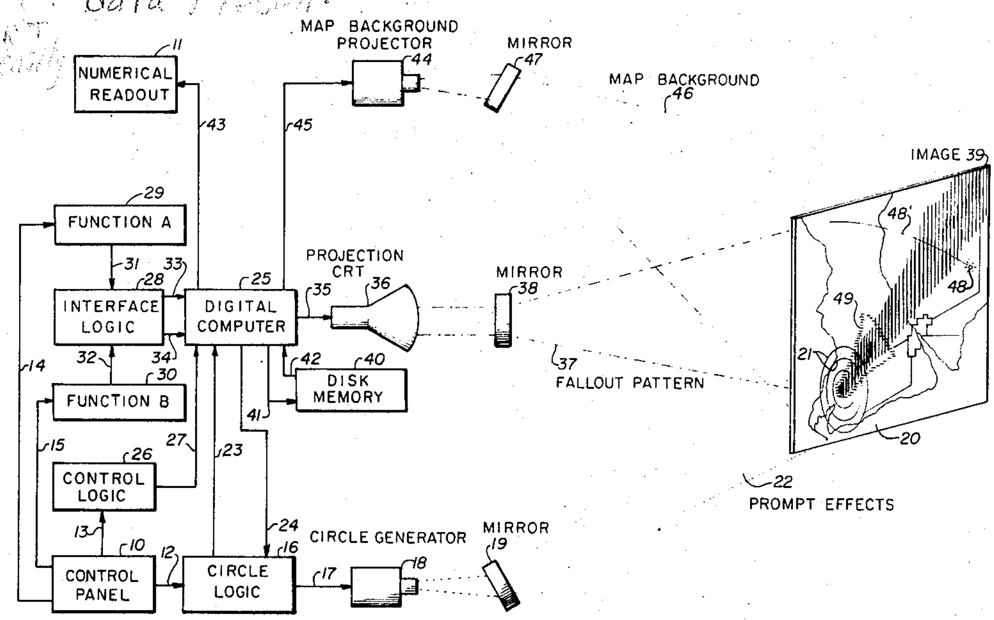
3,558,865 1/1971 Berndt................................235/151

Primary Examiner—Eugene G. Botz
Attorney—Roland A. Anderson

[57] **ABSTRACT**

A system for computing and displaying prompt and delayed effects of nuclear explosions with respect to a geographical area. The display is based on various input parameters concerning the initial conditions under which an explosive is detonated. The display is a superposition of prompt effects, viz., blast, thermal effects, etc., represented by concentric circles; fallout, represented by a time varying growing and variegated mosaic pattern; and a map whose scale is controllable upon command, this being accomplished by three separate images simultaneously projected on a screen from three separate sources. A computer controls the display and makes changes on it, utilizing relationships which characterize nuclear effects as functions of time. The apparatus is useful for understanding, analyzing, demonstrating and predicting the effects of nuclear weapons.

7 Claims, 45 Drawing Figures



43 Sheets-Sheet 1

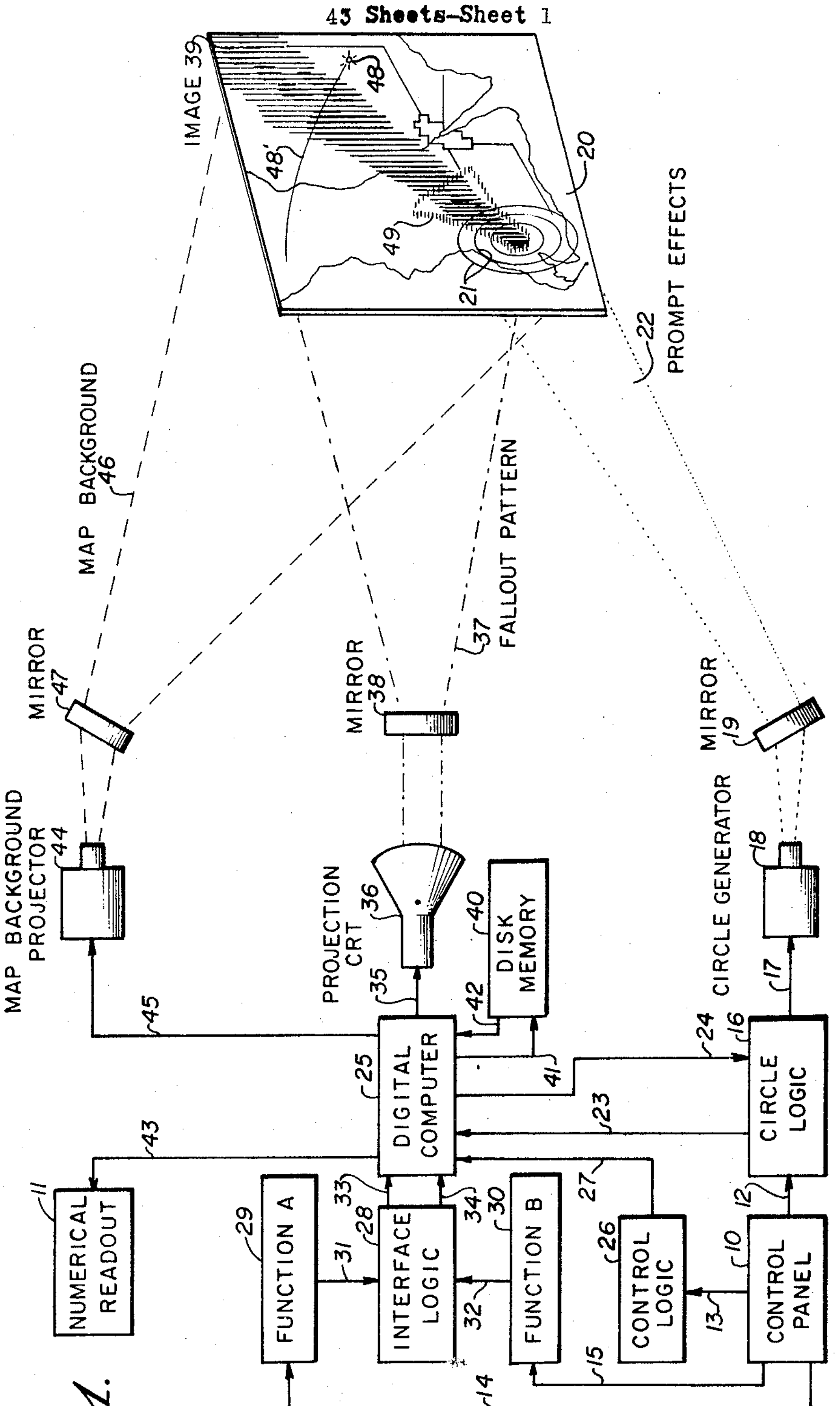


Fig. 1.

INVENTOR.
CARL W. BERNDT

BY

Ronald A. Anderson

ATTORNEY

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43 Sheets-Sheet 2

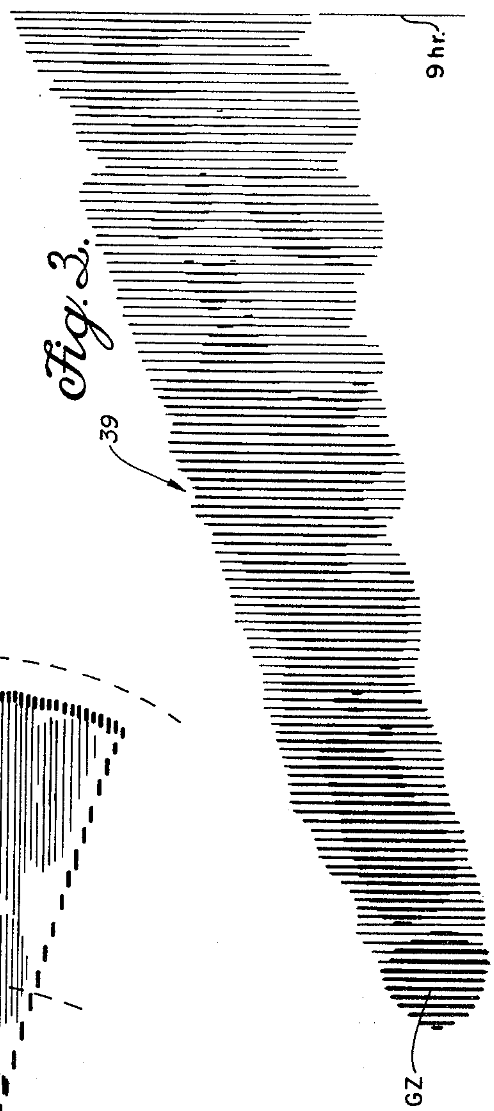

Fig. 3.

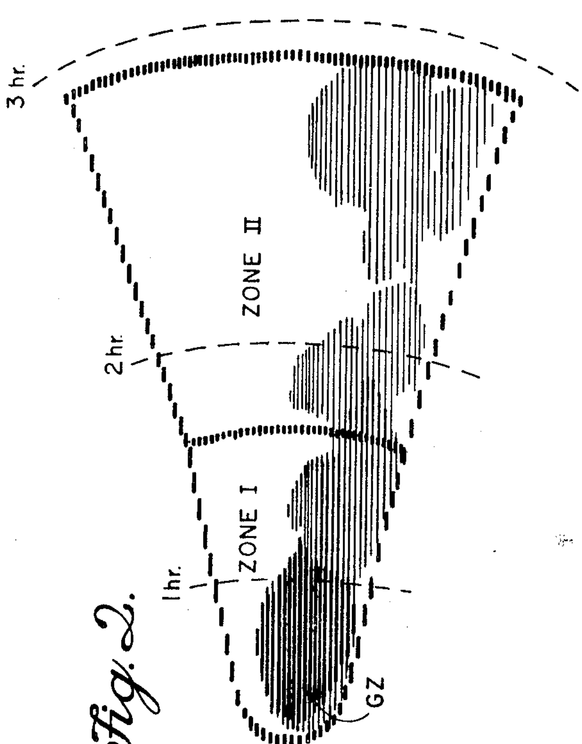

Fig. 2.

INVENTOR.
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BY

ATTORNEY

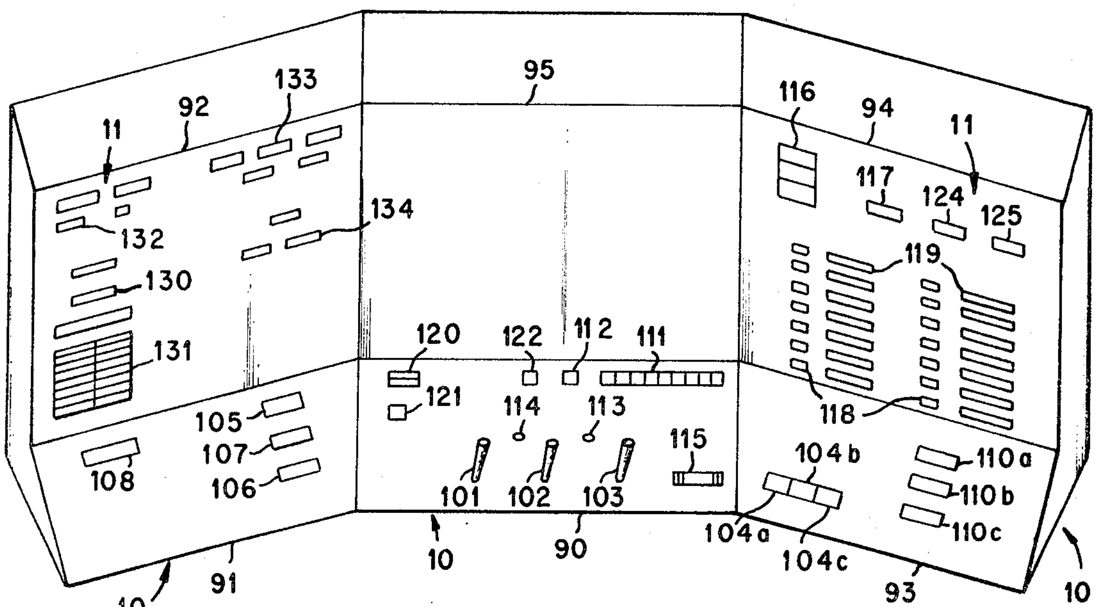

Fig. 4

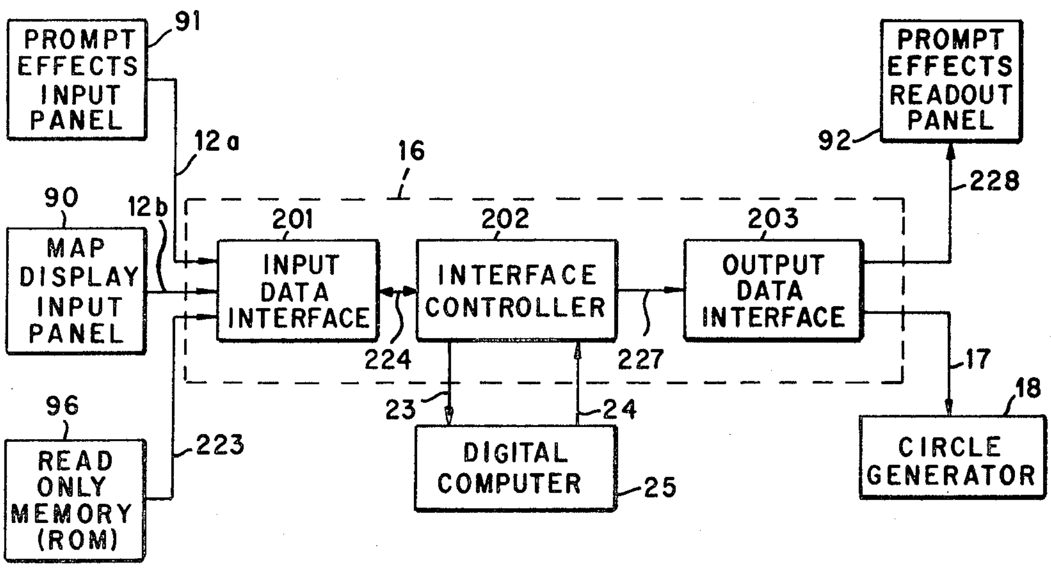

Fig. 5

INVENTOR.
Carl W. Berndt

BY

ATTORNEY.

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43 Sheets-Sheet 4

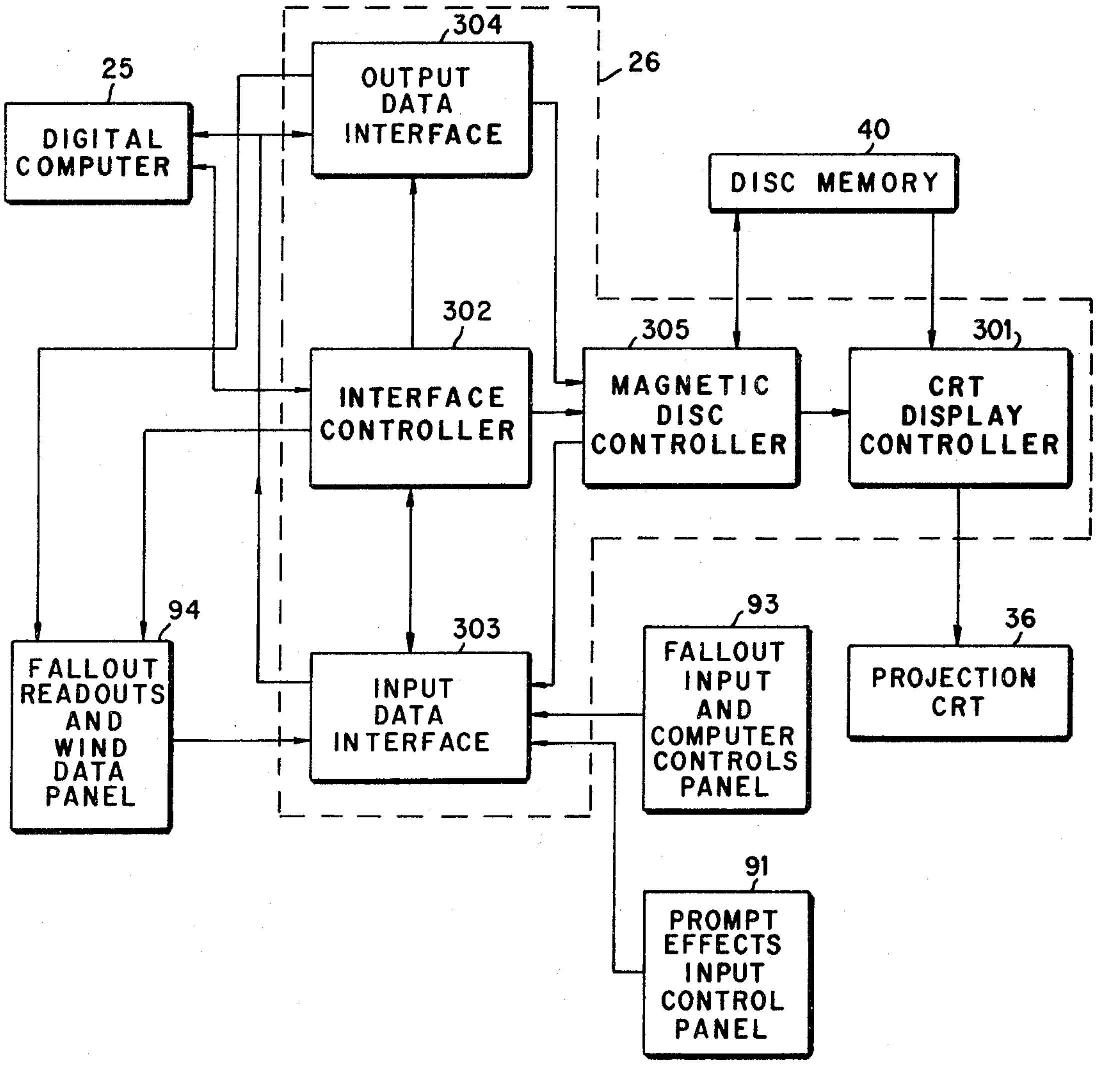


Fig. 6

INVENTOR.
Carl W. Berndt
BY
[signature]
ATTORNEY.

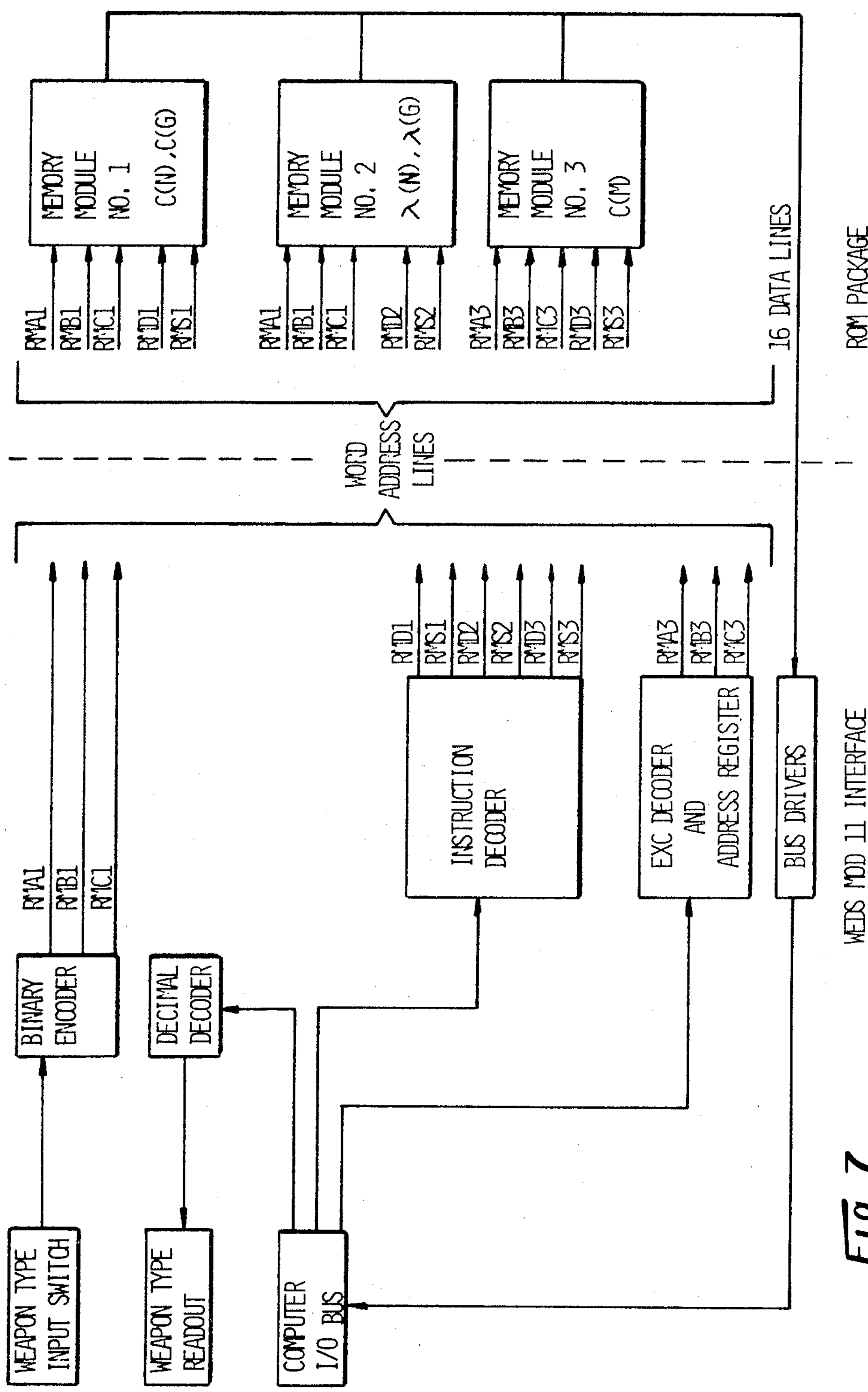
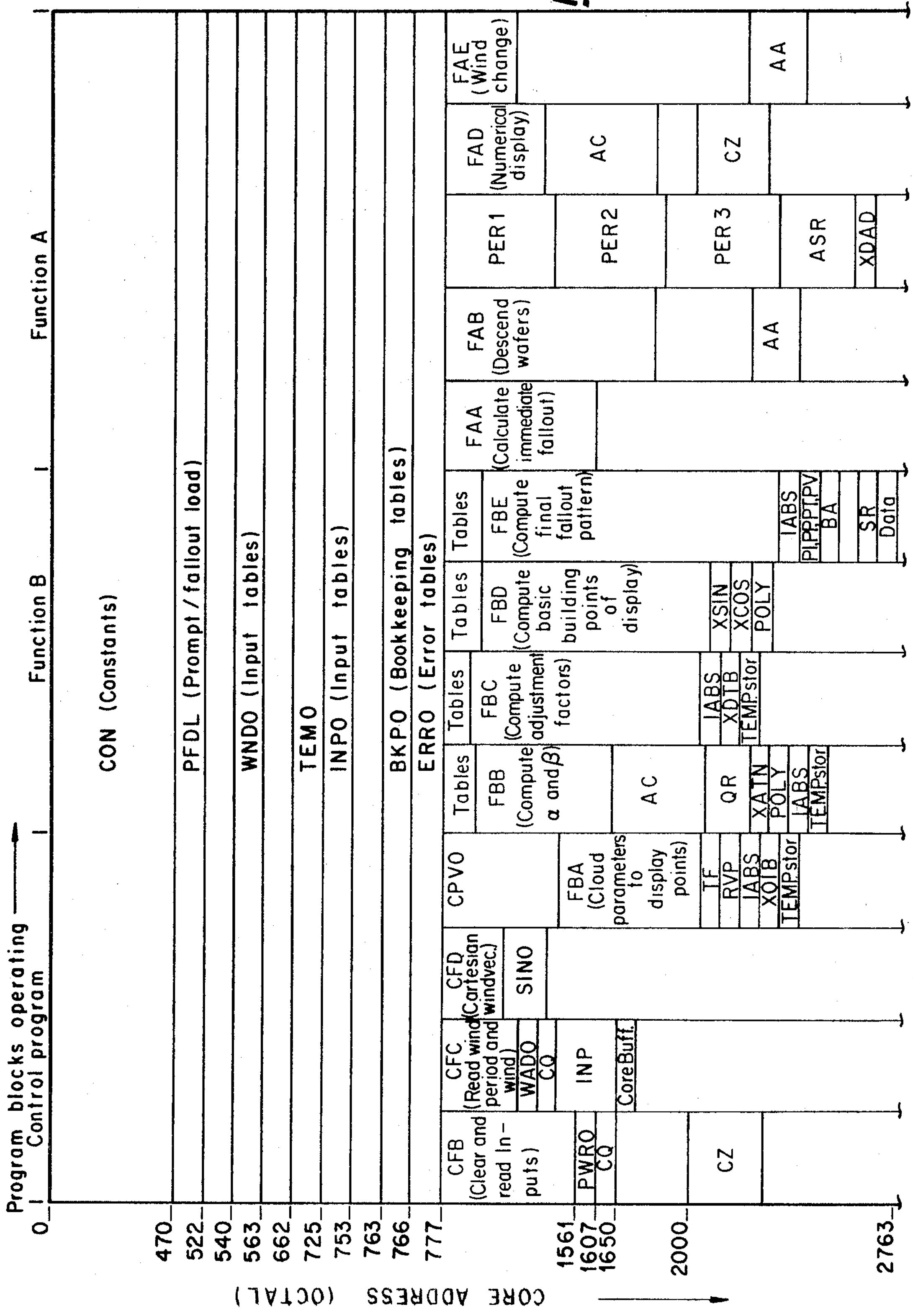

MEMORY MODULE NO. 1 C(N), C(G)
MEMORY MODULE NO. 2 λ(N), λ(G)
MEMORY MODULE NO. 3 C(M)
RMA1 RMB1 RMC1 RMD1 RMS1
RMA1 RMB1 RMC1 RMD2 RMS2
RMA3 RMB3 RMC3 RMD3 RMS3
16 DATA LINES
ROM PACKAGE
WORD ADDRESS LINES
RMD1 RMS1 RMD2 RMS2 RMD3 RMS3
RMA3 RMB3 RMC3
INSTRUCTION DECODER
EXC DECODER AND ADDRESS REGISTER
BUS DRIVERS
WEDS MOD 11 INTERFACE
RMA1 RMB1 RMC1
BINARY ENCODER
DECIMAL DECODER
WEAPON TYPE INPUT SWITCH
WEAPON TYPE READOUT
COMPUTER I/O BUS

Fig. 7

Fig. 8A


Program blocks operating
Control program
Function B
Function A
CON (Constants)
PFDL (Prompt / fallout load)
WNDO (Input tables)
TEMO
INPO (Input tables)
BKPO (Bookkeeping tables)
ERRO (Error tables)
CFB (Clear and read In-puts)
PWRO
CQ
CZ
CFC (Read wind period and wind)
WADO
CQ
INP
CoreBuff.
CFD (Cartesian windvec.)
SINO
CPVO
FBA (Cloud parameters to display points)
TF
RVP
IABS
XOIB
TEMPstor
Tables
FBB (Compute α and β)
AC
QR
XATN
POLY
IABS
TEMPstor
Tables
FBC (Compute adjustment factors)
IABS
XDTB
TEMPstor
Tables
FBD (Compute basic building points of display)
XSIN
XCOS
POLY
Tables
FBE (Compute final fallout pattern)
IABS
PI,PP,PT,PV
BA
SR
Data
FAA (Calculate immediate fallout)
FAB (Descend wafers)
AA
PER 1
PER 2
PER 3
ASR
XDAD
FAD (Numerical display)
AC
CZ
FAE (Wind change)
AA
0
470
522
540
563
662
725
753
763
766
777
1561
1607
1650
2000
2763
CORE ADDRESS (OCTAL)

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43 Sheets-Sheet 7

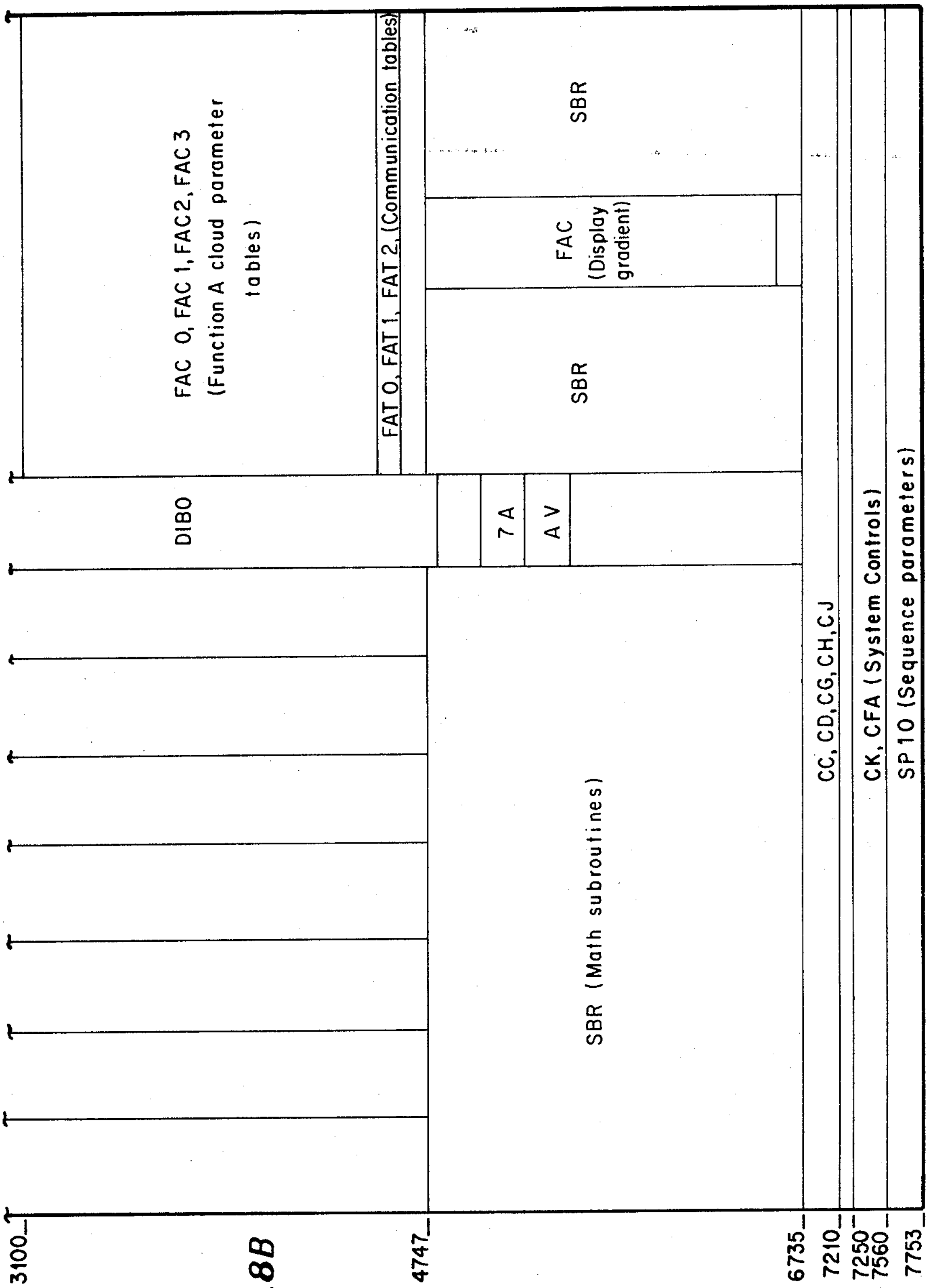

Fig. 8B

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45 Sheets-Sheet 8

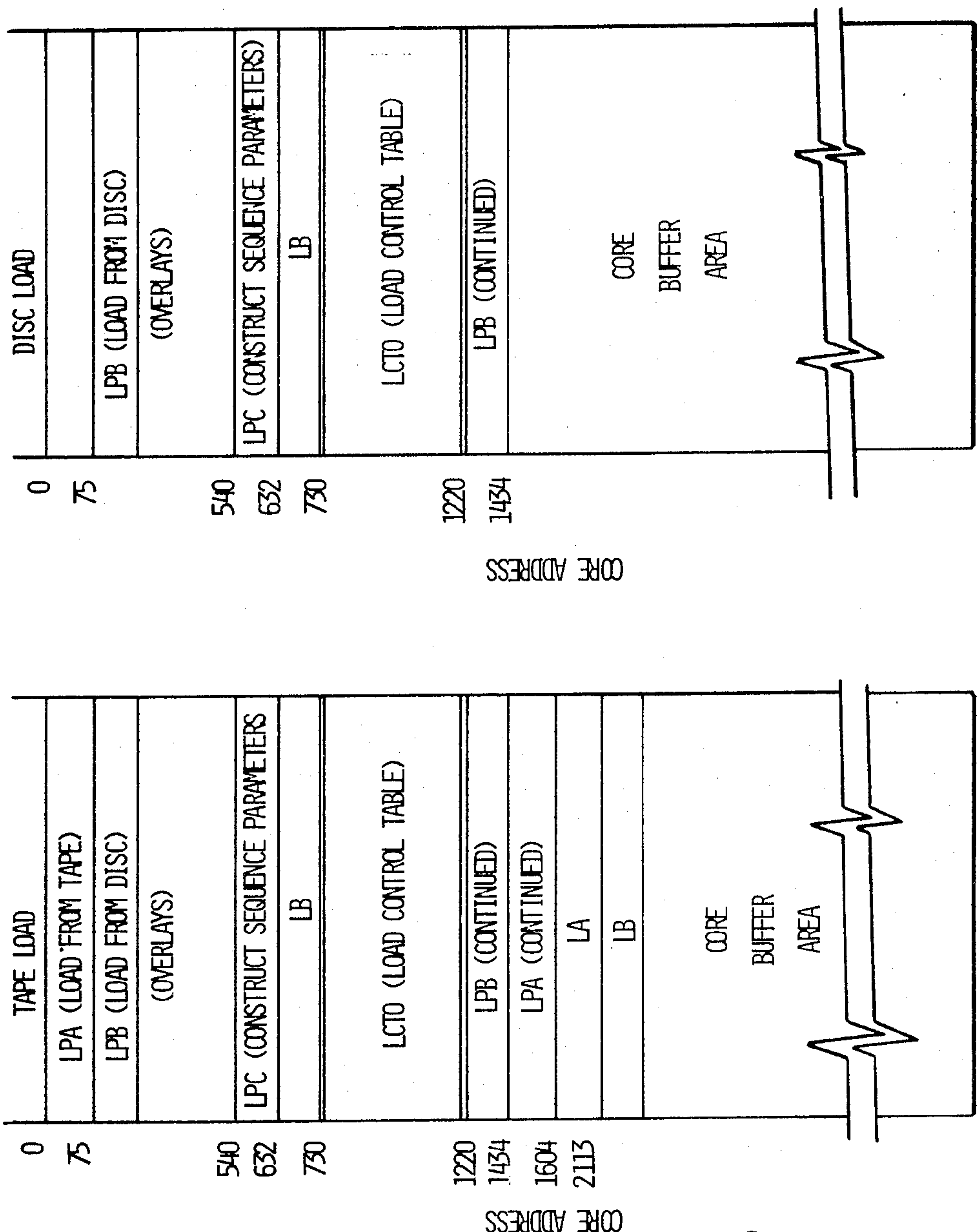

Fig. 9

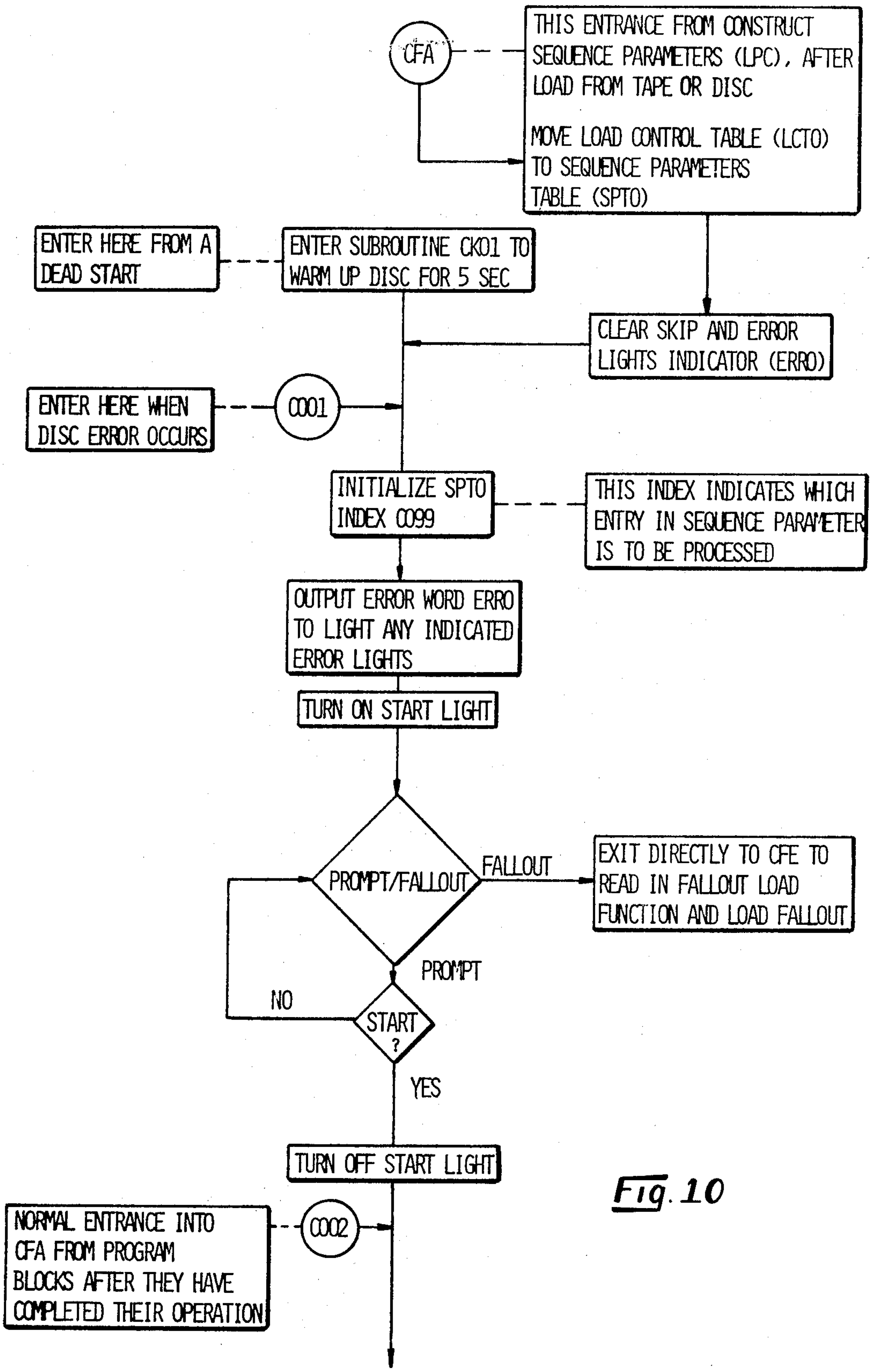
CFA
THIS ENTRANCE FROM CONSTRUCT SEQUENCE PARAMETERS (LPC), AFTER LOAD FROM TAPE OR DISC
MOVE LOAD CONTROL TABLE (LCTO) TO SEQUENCE PARAMETERS TABLE (SPTO)
ENTER HERE FROM A DEAD START
ENTER SUBROUTINE CK01 TO WARM UP DISC FOR 5 SEC
CLEAR SKIP AND ERROR LIGHTS INDICATOR (ERRO)
ENTER HERE WHEN DISC ERROR OCCURS
C001
INITIALIZE SPTO INDEX C099
THIS INDEX INDICATES WHICH ENTRY IN SEQUENCE PARAMETER IS TO BE PROCESSED
OUTPUT ERROR WORD ERRO TO LIGHT ANY INDICATED ERROR LIGHTS
TURN ON START LIGHT
PROMPT/FALLOUT
FALLOUT
EXIT DIRECTLY TO CFE TO READ IN FALLOUT LOAD FUNCTION AND LOAD FALLOUT
PROMPT
NO
START ?
YES
TURN OFF START LIGHT
NORMAL ENTRANCE INTO CFA FROM PROGRAM BLOCKS AFTER THEY HAVE COMPLETED THEIR OPERATION
C002

Fig. 10

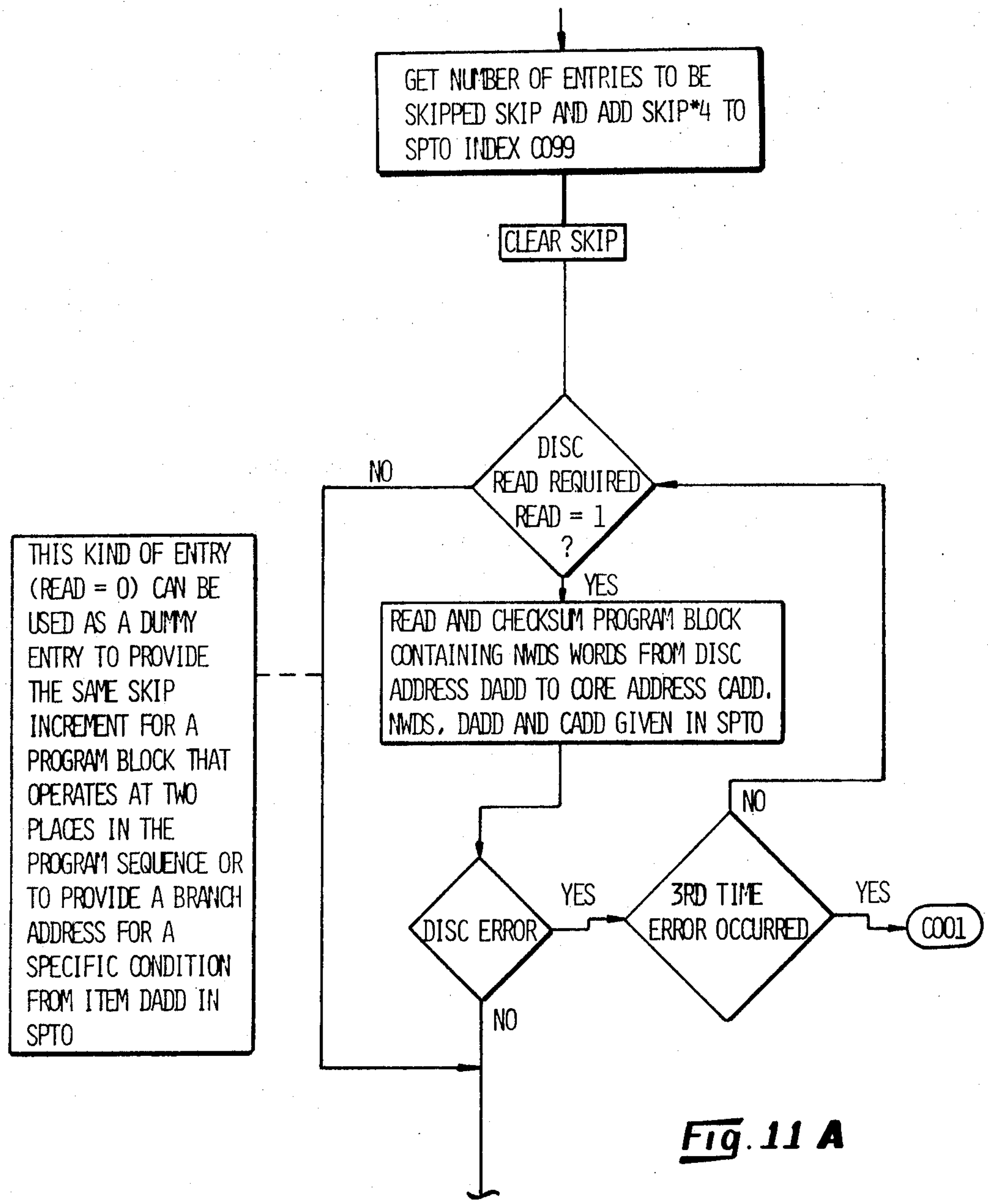
GET NUMBER OF ENTRIES TO BE SKIPPED SKIP AND ADD SKIP*4 TO SPTO INDEX C099
CLEAR SKIP
DISC READ REQUIRED READ = 1 ?
NO
YES
READ AND CHECKSUM PROGRAM BLOCK CONTAINING NWDS WORDS FROM DISC ADDRESS DADD TO CORE ADDRESS CADD. NWDS, DADD AND CADD GIVEN IN SPTO
THIS KIND OF ENTRY (READ = 0) CAN BE USED AS A DUMMY ENTRY TO PROVIDE THE SAME SKIP INCREMENT FOR A PROGRAM BLOCK THAT OPERATES AT TWO PLACES IN THE PROGRAM SEQUENCE OR TO PROVIDE A BRANCH ADDRESS FOR A SPECIFIC CONDITION FROM ITEM DADD IN SPTO
DISC ERROR
YES
NO
3RD TIME ERROR OCCURRED
NO
YES
C001

Fig. 11 A

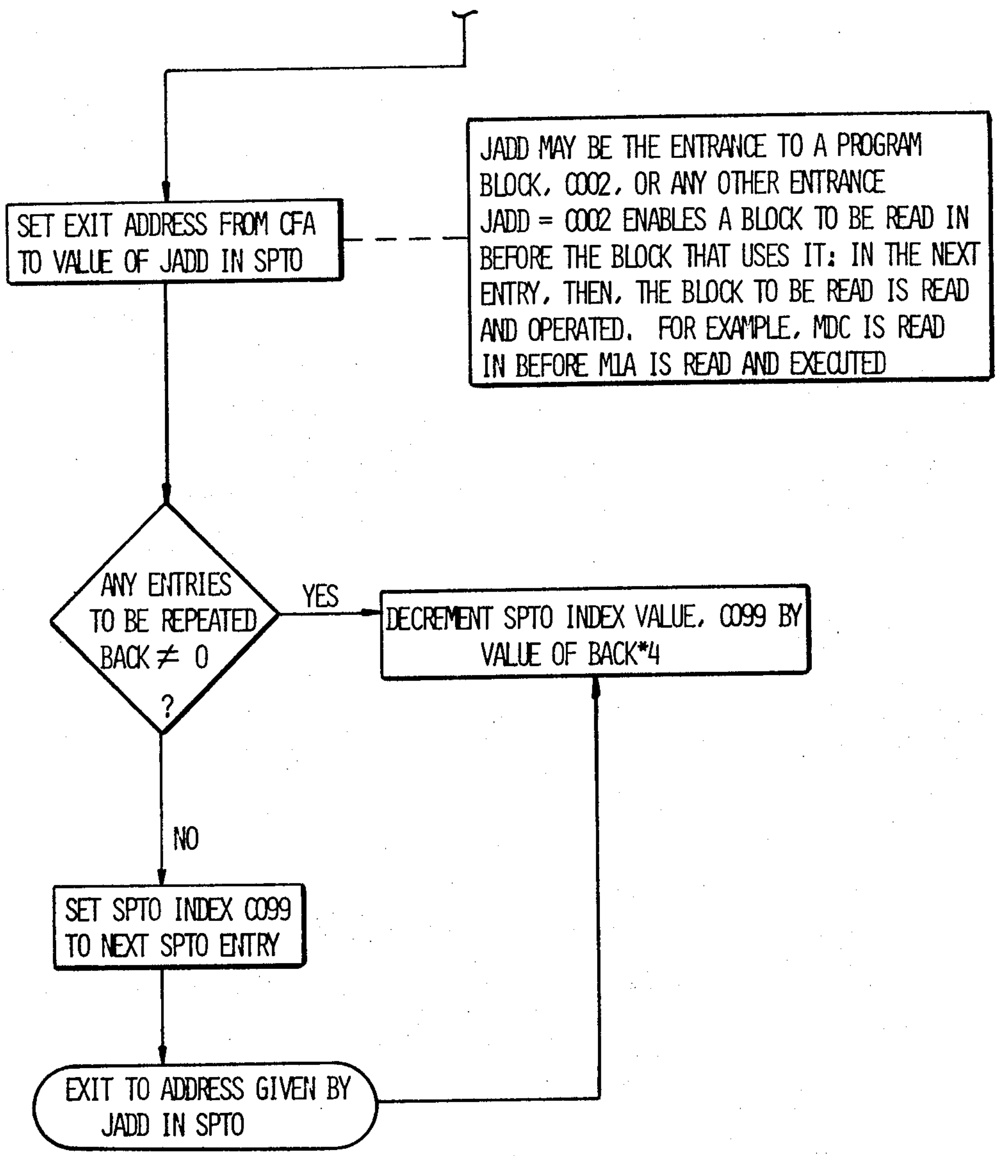
SET EXIT ADDRESS FROM CFA TO VALUE OF JADD IN SPTO
JADD MAY BE THE ENTRANCE TO A PROGRAM BLOCK, C002, OR ANY OTHER ENTRANCE JADD = C002 ENABLES A BLOCK TO BE READ IN BEFORE THE BLOCK THAT USES IT: IN THE NEXT ENTRY, THEN, THE BLOCK TO BE READ IS READ AND OPERATED. FOR EXAMPLE, MDC IS READ IN BEFORE M1A IS READ AND EXECUTED
ANY ENTRIES TO BE REPEATED BACK ≠ 0 ?
YES
DECREMENT SPTO INDEX VALUE, C099 BY VALUE OF BACK*4
NO
SET SPTO INDEX C099 TO NEXT SPTO ENTRY
EXIT TO ADDRESS GIVEN BY JADD IN SPTO

Fig. 11B

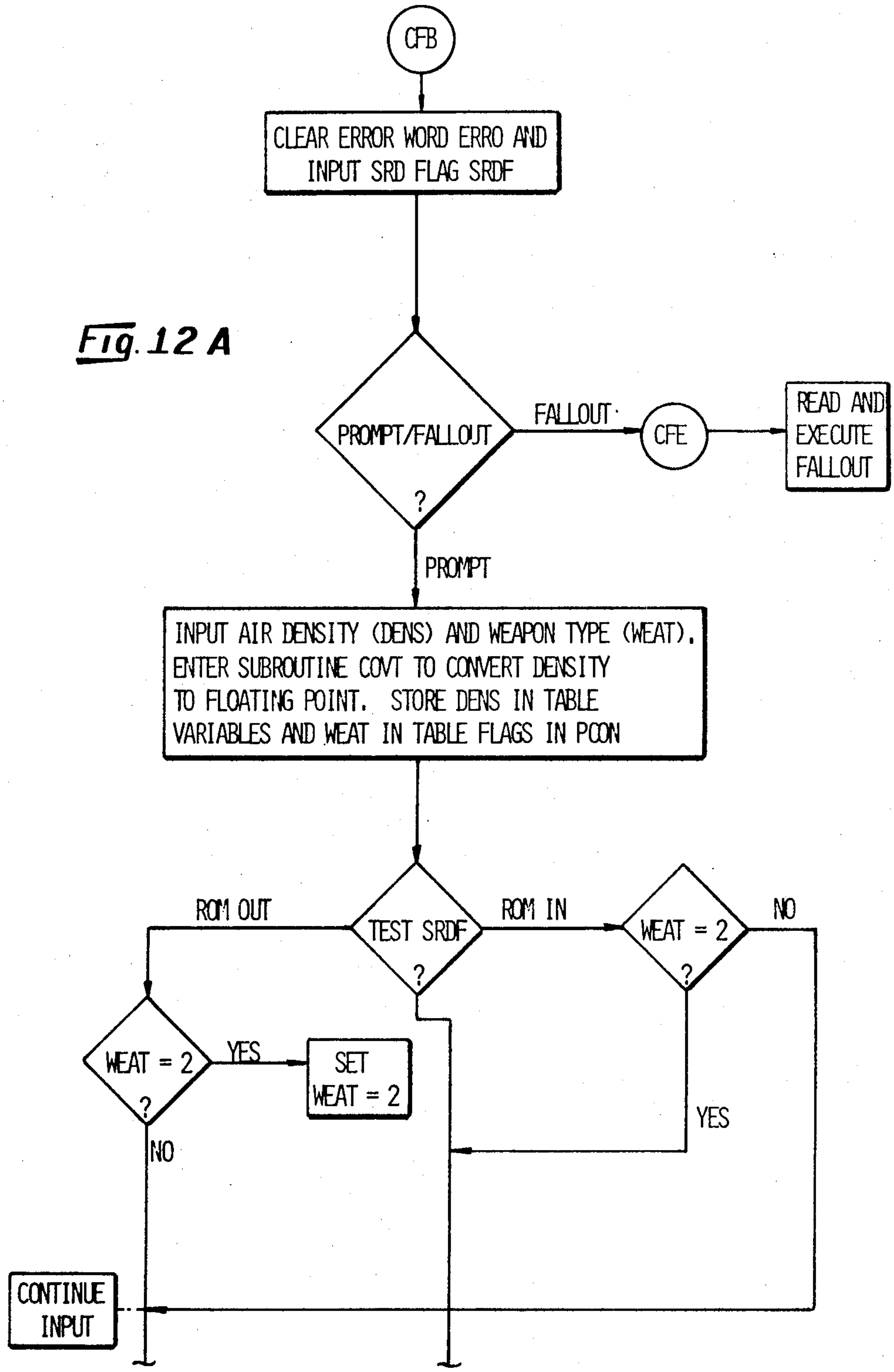
CFB
CLEAR ERROR WORD ERRO AND INPUT SRD FLAG SRDF
PROMPT/FALLOUT ?
FALLOUT
CFE
READ AND EXECUTE FALLOUT
PROMPT
INPUT AIR DENSITY (DENS) AND WEAPON TYPE (WEAT). ENTER SUBROUTINE COVT TO CONVERT DENSITY TO FLOATING POINT. STORE DENS IN TABLE VARIABLES AND WEAT IN TABLE FLAGS IN PCON
ROM OUT
TEST SRDF ?
ROM IN
WEAT = 2 ?
NO
WEAT = 2 ?
YES
SET WEAT = 2
NO
YES
CONTINUE INPUT

Fig. 12 A

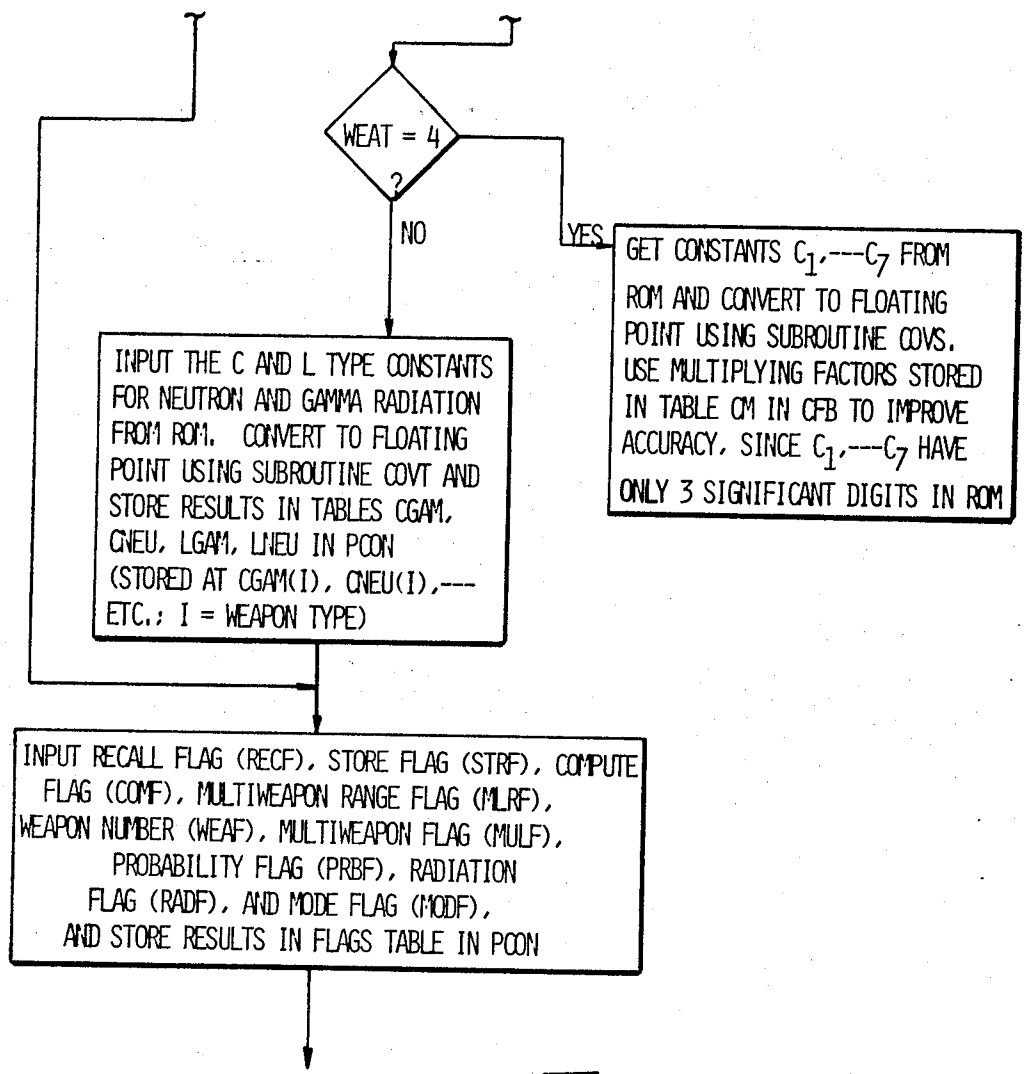
WEAT = 4 ?
NO
YES
GET CONSTANTS C1,---C7 FROM ROM AND CONVERT TO FLOATING POINT USING SUBROUTINE COVS. USE MULTIPLYING FACTORS STORED IN TABLE CM IN CFB TO IMPROVE ACCURACY, SINCE C1,---C7 HAVE ONLY 3 SIGNIFICANT DIGITS IN ROM
INPUT THE C AND L TYPE CONSTANTS FOR NEUTRON AND GAMMA RADIATION FROM ROM. CONVERT TO FLOATING POINT USING SUBROUTINE COVT AND STORE RESULTS IN TABLES CGAM, CNEU, LGAM, LNEU IN PCON (STORED AT CGAM(I), CNEU(I),--- ETC.; I = WEAPON TYPE)
INPUT RECALL FLAG (RECF), STORE FLAG (STRF), COMPUTE FLAG (COMF), MULTIWEAPON RANGE FLAG (MLRF), WEAPON NUMBER (WEAF), MULTIWEAPON FLAG (MULF), PROBABILITY FLAG (PRBF), RADIATION FLAG (RADF), AND MODE FLAG (MODF), AND STORE RESULTS IN FLAGS TABLE IN PCON

Fig. 12B

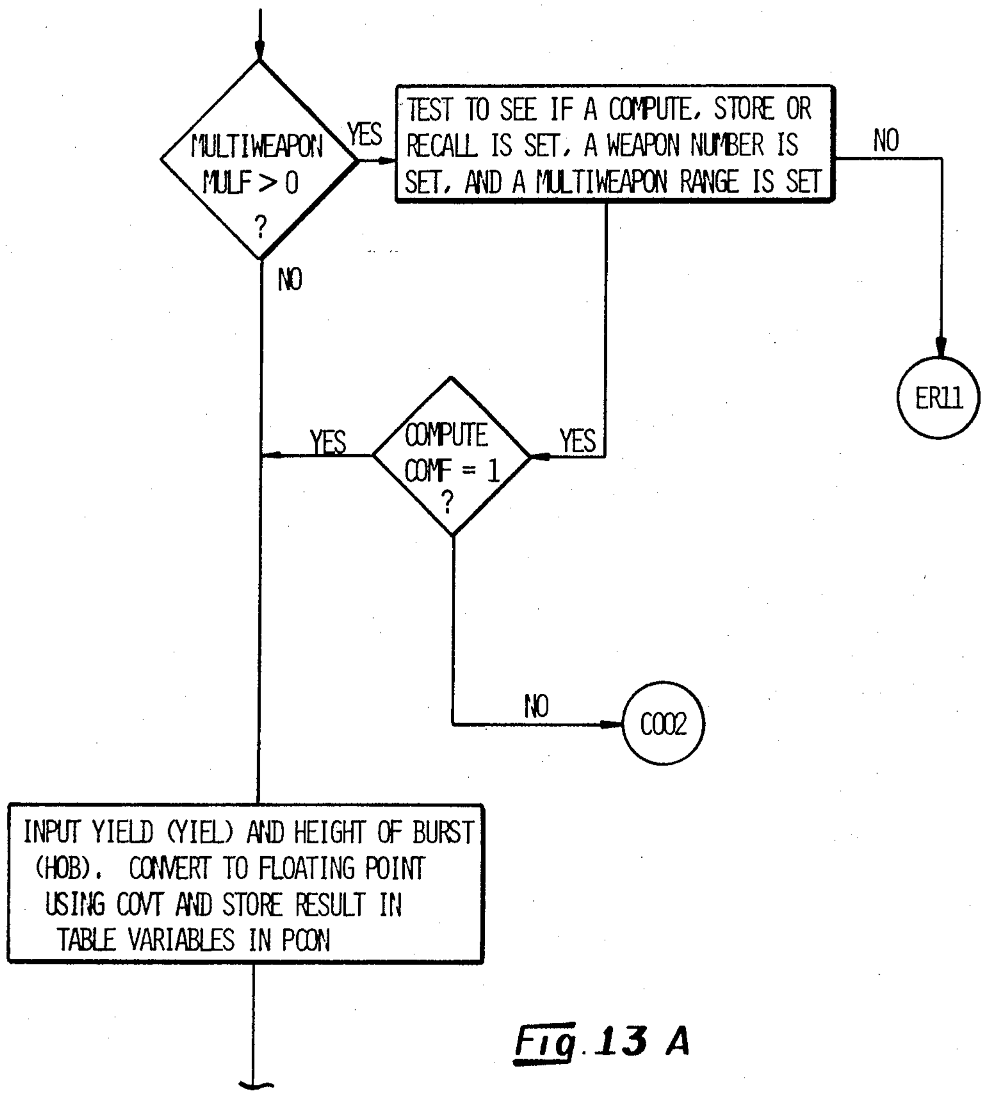
MULTIWEAPON
MULF > 0
?
YES
TEST TO SEE IF A COMPUTE, STORE OR RECALL IS SET, A WEAPON NUMBER IS SET, AND A MULTIWEAPON RANGE IS SET
NO
ER11
NO
YES
COMPUTE
COMF = 1
?
YES
NO
C002
INPUT YIELD (YIEL) AND HEIGHT OF BURST (HOB). CONVERT TO FLOATING POINT USING COVT AND STORE RESULT IN TABLE VARIABLES IN PCON

Fig. 13 A

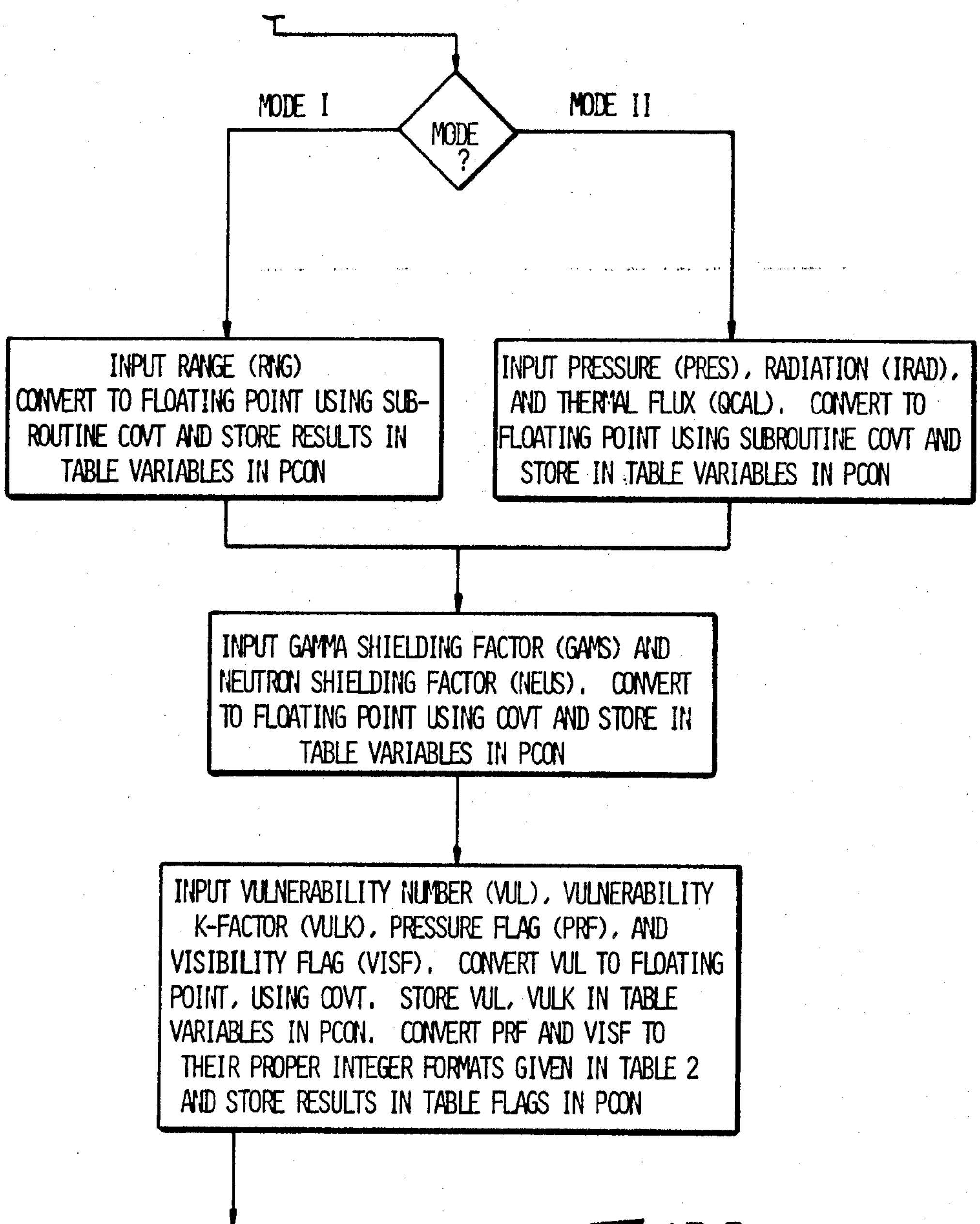
MODE I
MODE ?
MODE II
INPUT RANGE (RNG) CONVERT TO FLOATING POINT USING SUB-ROUTINE COVT AND STORE RESULTS IN TABLE VARIABLES IN PCON
INPUT PRESSURE (PRES), RADIATION (IRAD), AND THERMAL FLUX (QCAL). CONVERT TO FLOATING POINT USING SUBROUTINE COVT AND STORE IN TABLE VARIABLES IN PCON
INPUT GAMMA SHIELDING FACTOR (GAMS) AND NEUTRON SHIELDING FACTOR (NEUS). CONVERT TO FLOATING POINT USING COVT AND STORE IN TABLE VARIABLES IN PCON
INPUT VULNERABILITY NUMBER (VUL), VULNERABILITY K-FACTOR (VULK), PRESSURE FLAG (PRF), AND VISIBILITY FLAG (VISF). CONVERT VUL TO FLOATING POINT, USING COVT. STORE VUL, VULK IN TABLE VARIABLES IN PCON. CONVERT PRF AND VISF TO THEIR PROPER INTEGER FORMATS GIVEN IN TABLE 2 AND STORE RESULTS IN TABLE FLAGS IN PCON

Fig. 13 B

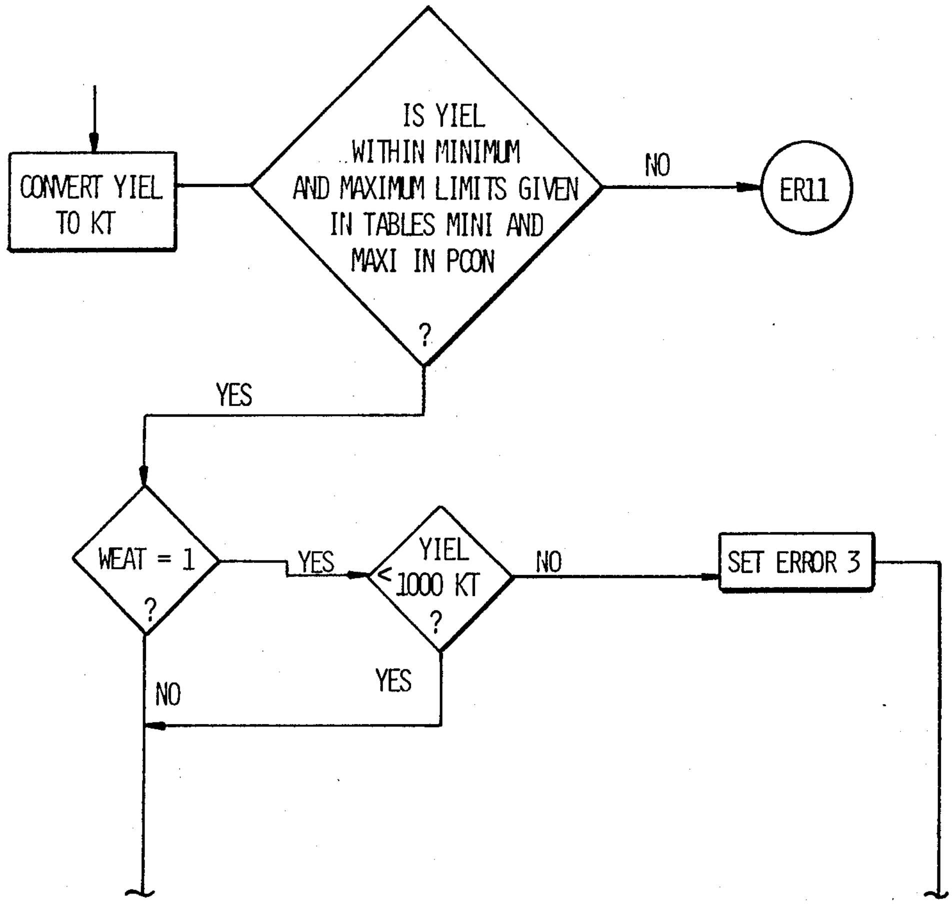
CONVERT YIEL TO KT
IS YIEL WITHIN MINIMUM AND MAXIMUM LIMITS GIVEN IN TABLES MINI AND MAXI IN PCON ?
NO
ER11
YES
WEAT = 1 ?
YES
YIEL < 1000 KT ?
NO
SET ERROR 3
YES
NO

Fig. 14A

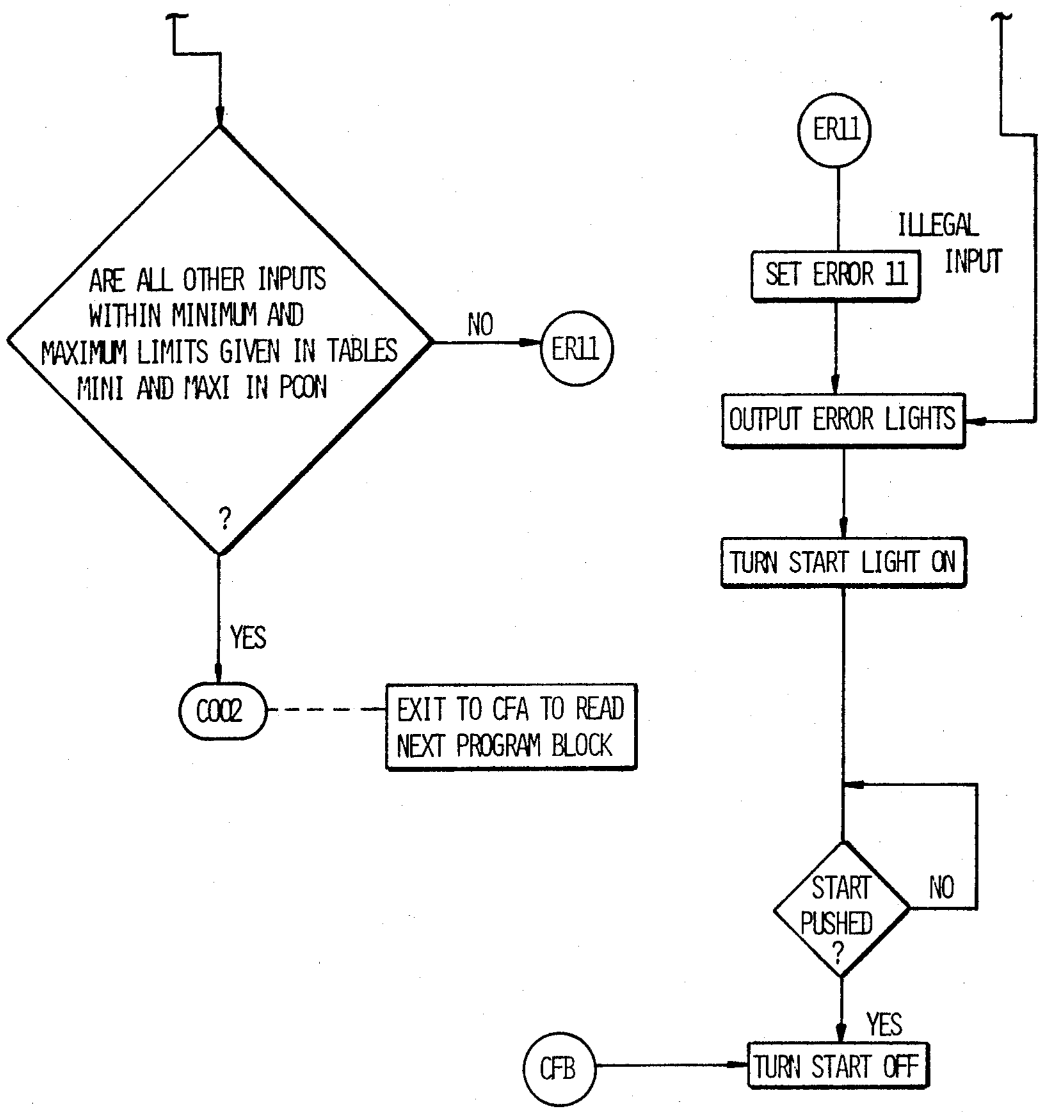
ARE ALL OTHER INPUTS WITHIN MINIMUM AND MAXIMUM LIMITS GIVEN IN TABLES MINI AND MAXI IN PCON ?
NO
ER11
YES
C002
EXIT TO CFA TO READ NEXT PROGRAM BLOCK
ER11
ILLEGAL INPUT
SET ERROR 11
OUTPUT ERROR LIGHTS
TURN START LIGHT ON
START PUSHED ?
NO
YES
CFB
TURN START OFF

Fig. 14B

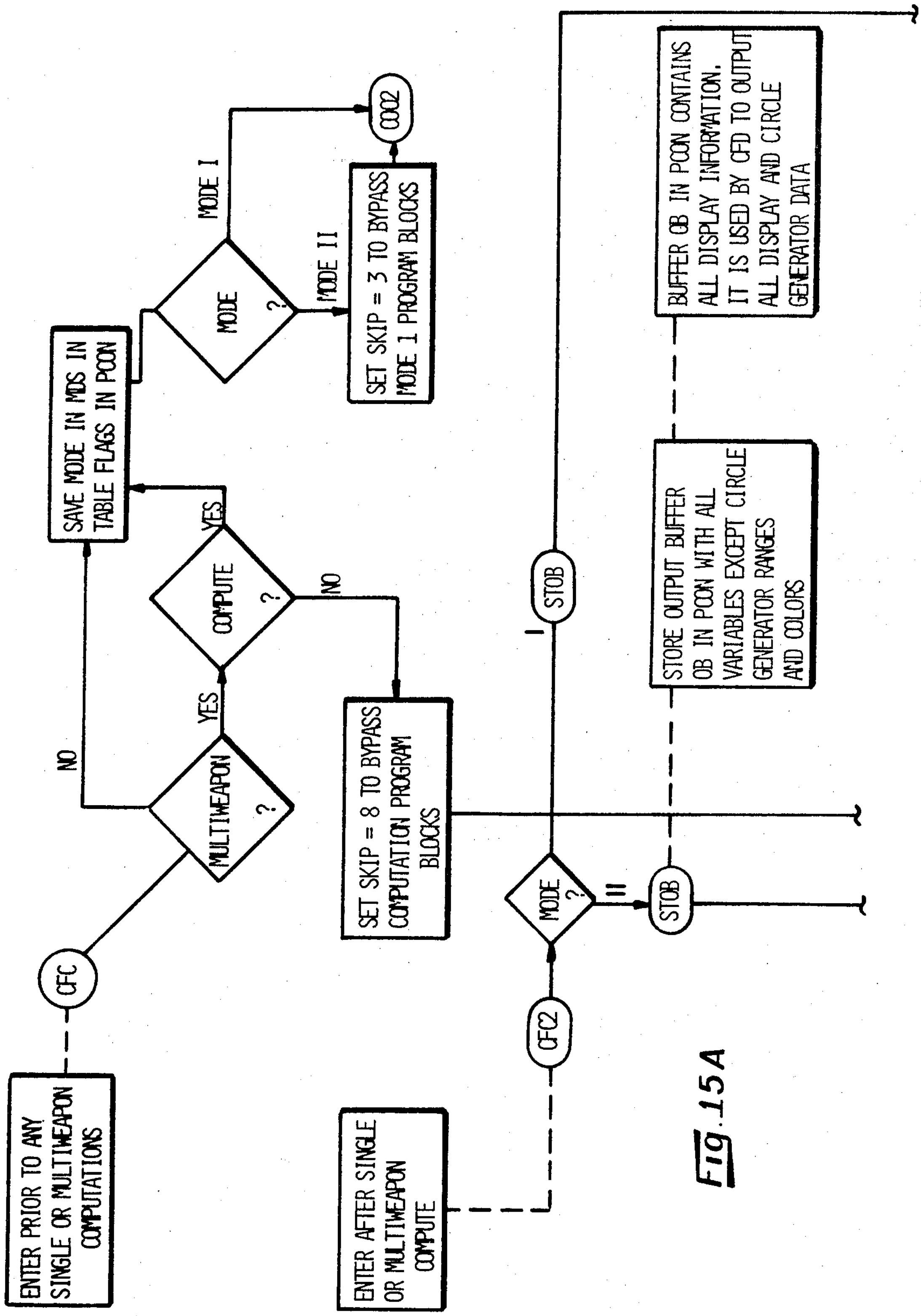
ENTER PRIOR TO ANY SINGLE OR MULTIWEAPON COMPUTATIONS
CFC
MULTIWEAPON ?
NO
YES
COMPUTE ?
YES
NO
SAVE MODE IN MDS IN TABLE FLAGS IN PCON
MODE ?
MODE I
MODE II
SET SKIP = 3 TO BYPASS MODE 1 PROGRAM BLOCKS
COO2
SET SKIP = 8 TO BYPASS COMPUTATION PROGRAM BLOCKS
ENTER AFTER SINGLE OR MULTIWEAPON COMPUTE
CFC2
MODE ?
I
II
STOB
STOB
STORE OUTPUT BUFFER OB IN PCON WITH ALL VARIABLES EXCEPT CIRCLE GENERATOR RANGES AND COLORS
BUFFER OB IN PCON CONTAINS ALL DISPLAY INFORMATION. IT IS USED BY CFD TO OUTPUT ALL DISPLAY AND CIRCLE GENERATOR DATA

Fig. 15A

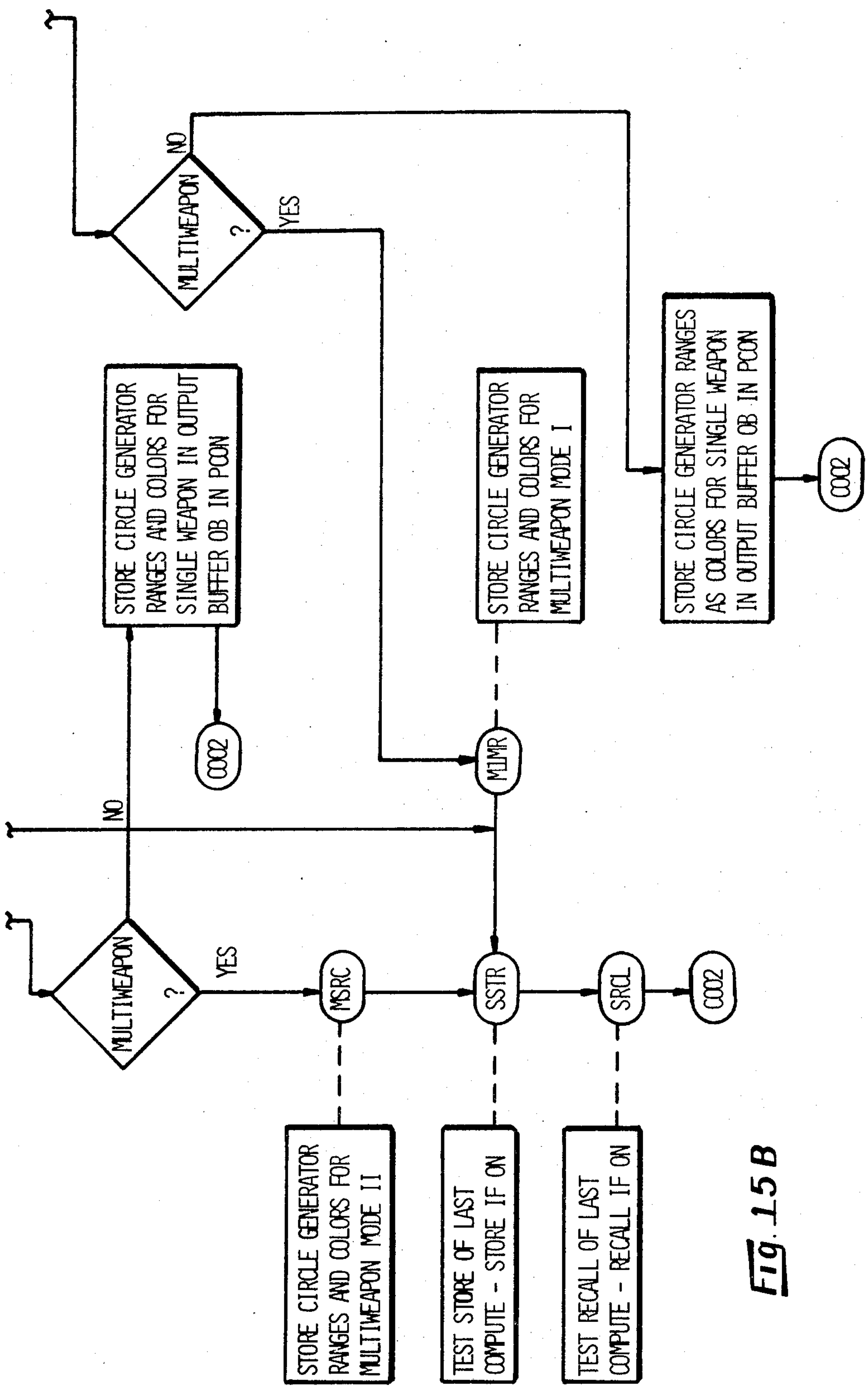
MULTIWEAPON ?
NO
YES
STORE CIRCLE GENERATOR RANGES AND COLORS FOR SINGLE WEAPON IN OUTPUT BUFFER OB IN PCON
CO02
STORE CIRCLE GENERATOR RANGES AND COLORS FOR MULTIWEAPON MODE I
M1MR
STORE CIRCLE GENERATOR RANGES AS COLORS FOR SINGLE WEAPON IN OUTPUT BUFFER OB IN PCON
CO02
MULTIWEAPON ?
NO
YES
MSRC
SSTR
SRCL
CO02
STORE CIRCLE GENERATOR RANGES AND COLORS FOR MULTIWEAPON MODE II
TEST STORE OF LAST COMPUTE - STORE IF ON
TEST RECALL OF LAST COMPUTE - RECALL IF ON

Fig. 15B

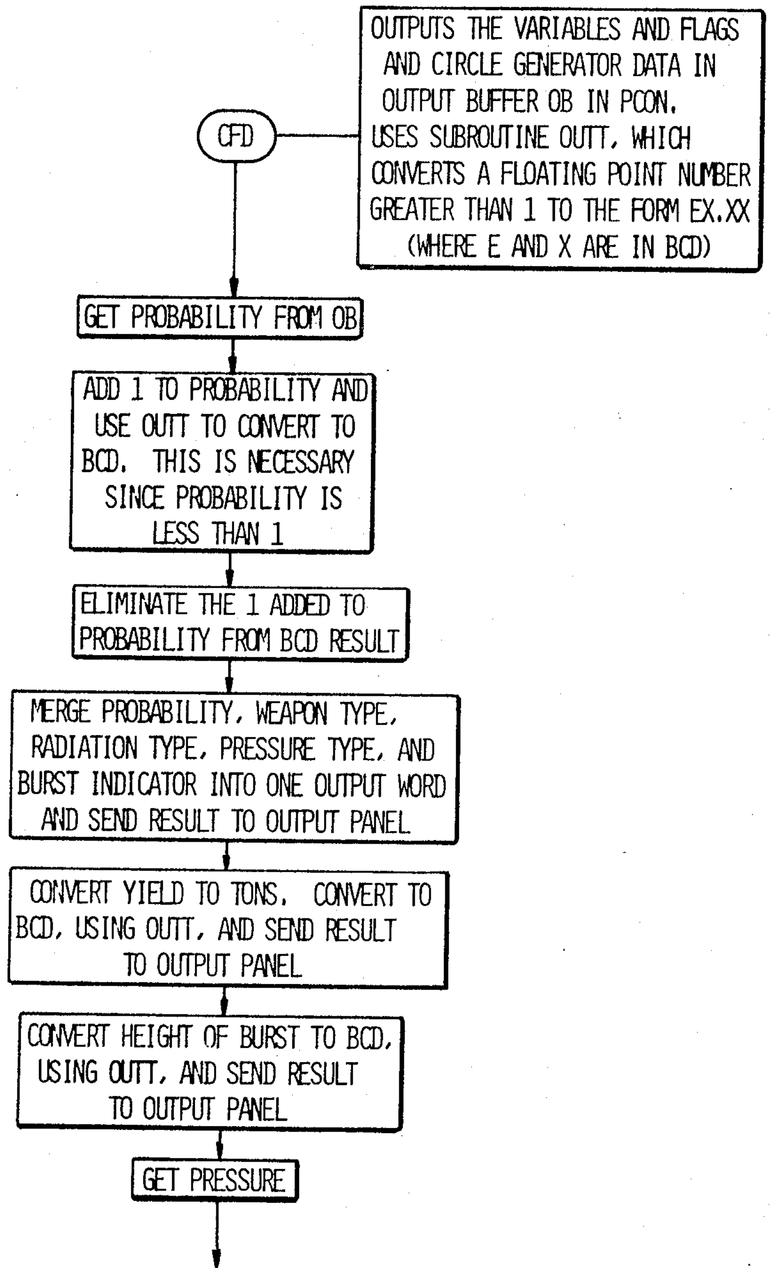
OUTPUTS THE VARIABLES AND FLAGS AND CIRCLE GENERATOR DATA IN OUTPUT BUFFER OB IN PCON. USES SUBROUTINE OUTT, WHICH CONVERTS A FLOATING POINT NUMBER GREATER THAN 1 TO THE FORM EX.XX (WHERE E AND X ARE IN BCD)
CFD
GET PROBABILITY FROM OB
ADD 1 TO PROBABILITY AND USE OUTT TO CONVERT TO BCD. THIS IS NECESSARY SINCE PROBABILITY IS LESS THAN 1
ELIMINATE THE 1 ADDED TO PROBABILITY FROM BCD RESULT
MERGE PROBABILITY, WEAPON TYPE, RADIATION TYPE, PRESSURE TYPE, AND BURST INDICATOR INTO ONE OUTPUT WORD AND SEND RESULT TO OUTPUT PANEL
CONVERT YIELD TO TONS. CONVERT TO BCD, USING OUTT, AND SEND RESULT TO OUTPUT PANEL
CONVERT HEIGHT OF BURST TO BCD, USING OUTT, AND SEND RESULT TO OUTPUT PANEL
GET PRESSURE

Fig. 16

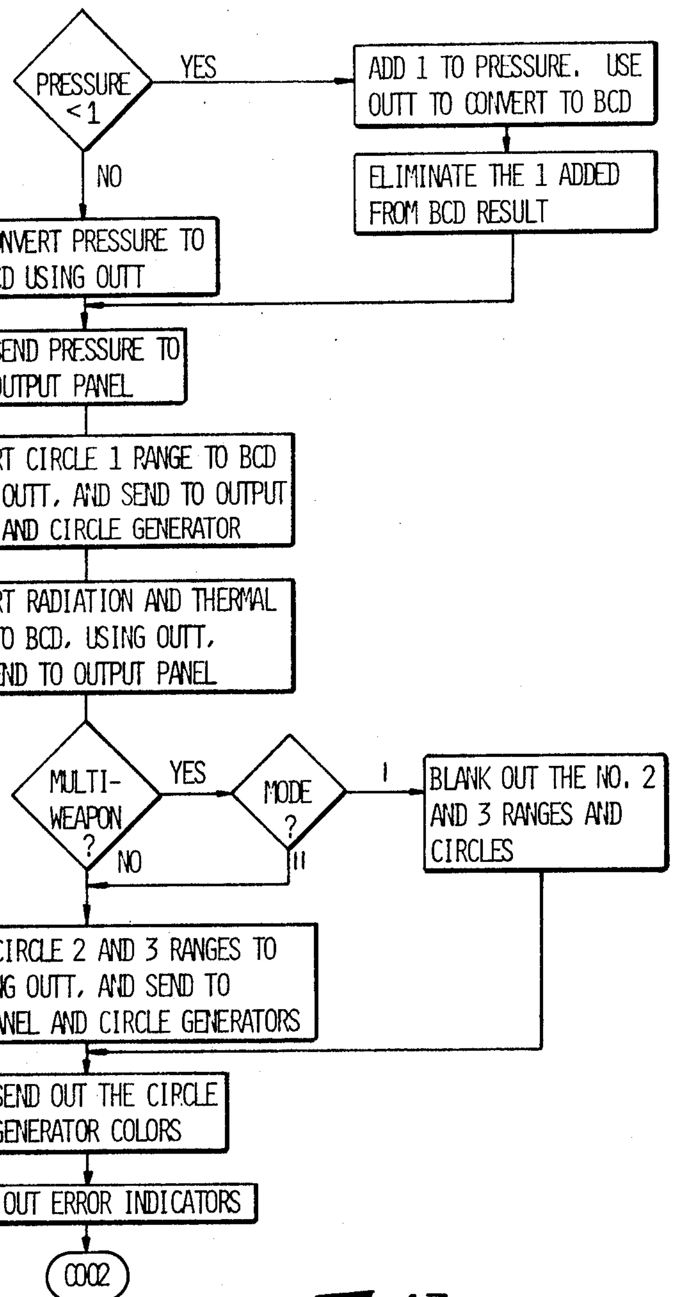
PRESSURE <1
YES
ADD 1 TO PRESSURE. USE OUTT TO CONVERT TO BCD
ELIMINATE THE 1 ADDED FROM BCD RESULT
NO
CONVERT PRESSURE TO BCD USING OUTT
SEND PRESSURE TO OUTPUT PANEL
CONVERT CIRCLE 1 RANGE TO BCD USING OUTT, AND SEND TO OUTPUT PANEL AND CIRCLE GENERATOR
CONVERT RADIATION AND THERMAL FLUX TO BCD, USING OUTT, AND SEND TO OUTPUT PANEL
MULTI-WEAPON ?
YES
MODE ?
I
BLANK OUT THE NO. 2 AND 3 RANGES AND CIRCLES
NO
II
CONVERT CIRCLE 2 AND 3 RANGES TO BCD, USING OUTT, AND SEND TO OUTPUT PANEL AND CIRCLE GENERATORS
SEND OUT THE CIRCLE GENERATOR COLORS
SEND OUT ERROR INDICATORS
C002

Fig. 17

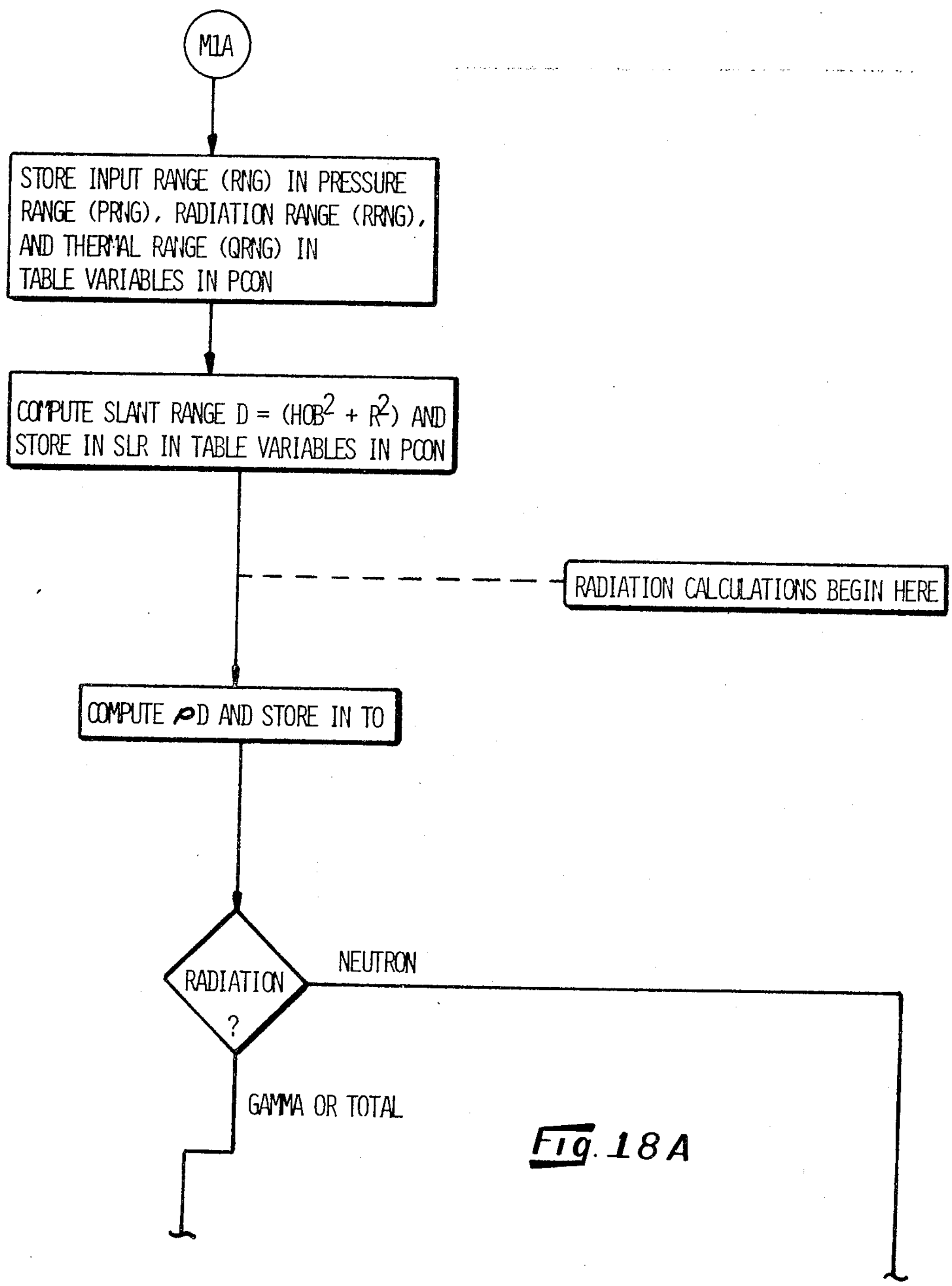
M1A
STORE INPUT RANGE (RNG) IN PRESSURE RANGE (PRNG), RADIATION RANGE (RRNG), AND THERMAL RANGE (QRNG) IN TABLE VARIABLES IN PCON
COMPUTE SLANT RANGE D = (HOB2 + R2) AND STORE IN SLR IN TABLE VARIABLES IN PCON
RADIATION CALCULATIONS BEGIN HERE
COMPUTE ρD AND STORE IN TO
RADIATION ?
NEUTRON
GAMMA OR TOTAL

Fig. 18A

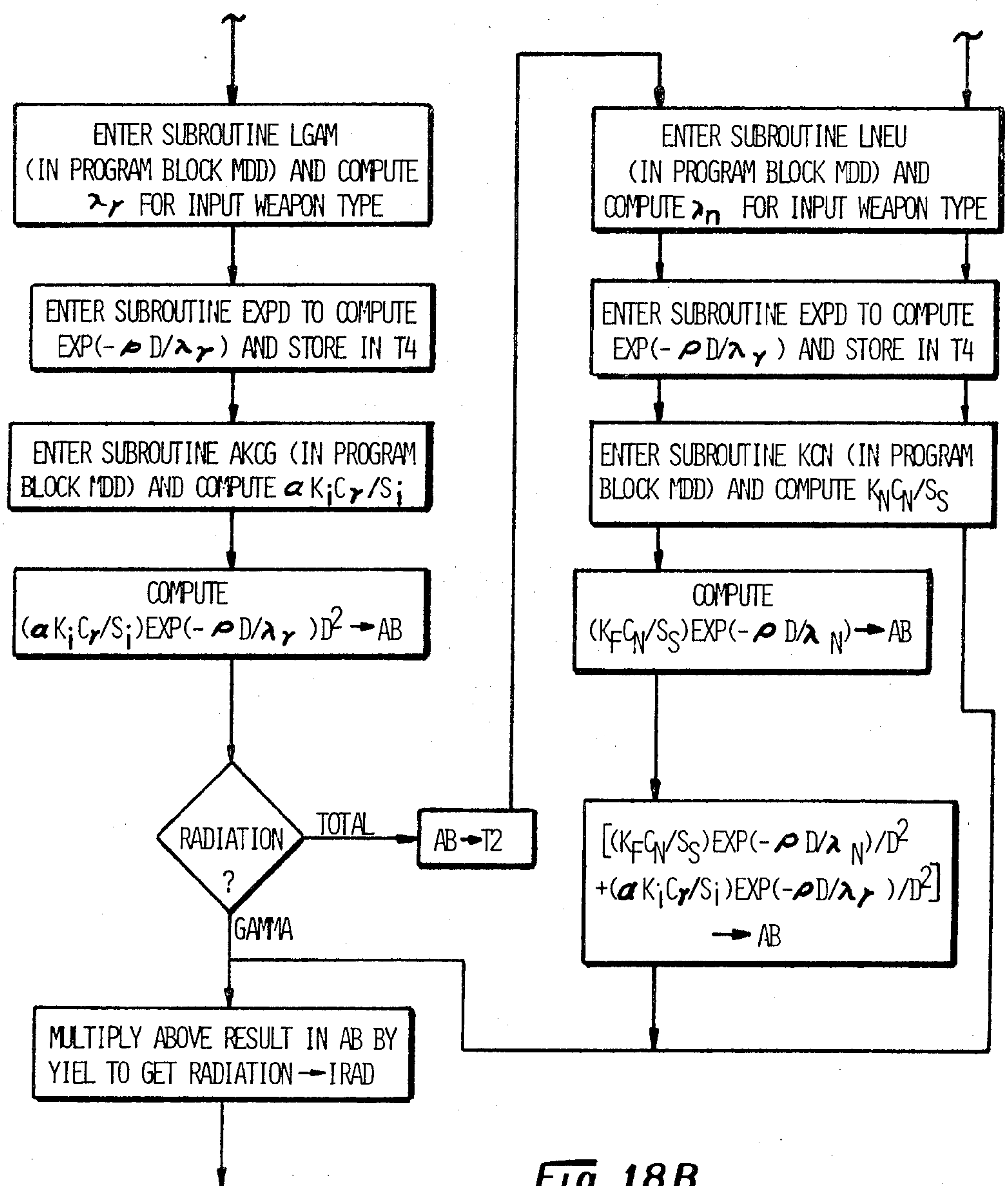
ENTER SUBROUTINE LGAM (IN PROGRAM BLOCK MDD) AND COMPUTE λ_γ FOR INPUT WEAPON TYPE
ENTER SUBROUTINE EXPD TO COMPUTE EXP(-ρ D/λ_γ) AND STORE IN T4
ENTER SUBROUTINE AKCG (IN PROGRAM BLOCK MDD) AND COMPUTE $\alpha K_i C_\gamma / S_i$
COMPUTE $(\alpha K_i C_\gamma/S_i) EXP(-\rho D/\lambda_\gamma) D^2 \rightarrow AB$
RADIATION ?
TOTAL
GAMMA
AB→T2
MULTIPLY ABOVE RESULT IN AB BY YIEL TO GET RADIATION→IRAD
ENTER SUBROUTINE LNEU (IN PROGRAM BLOCK MDD) AND COMPUTE λ_n FOR INPUT WEAPON TYPE
ENTER SUBROUTINE EXPD TO COMPUTE EXP(-ρ D/λ_γ) AND STORE IN T4
ENTER SUBROUTINE KCN (IN PROGRAM BLOCK MDD) AND COMPUTE $K_N C_N / S_S$
COMPUTE $(K_F C_N/S_S) EXP(-\rho D/\lambda_N) \rightarrow AB$
$[(K_F C_N/S_S) EXP(-\rho D/\lambda_N)/D^2 + (\alpha K_i C_\gamma/S_i) EXP(-\rho D/\lambda_\gamma)/D^2] \rightarrow AB$

Fig. 18B

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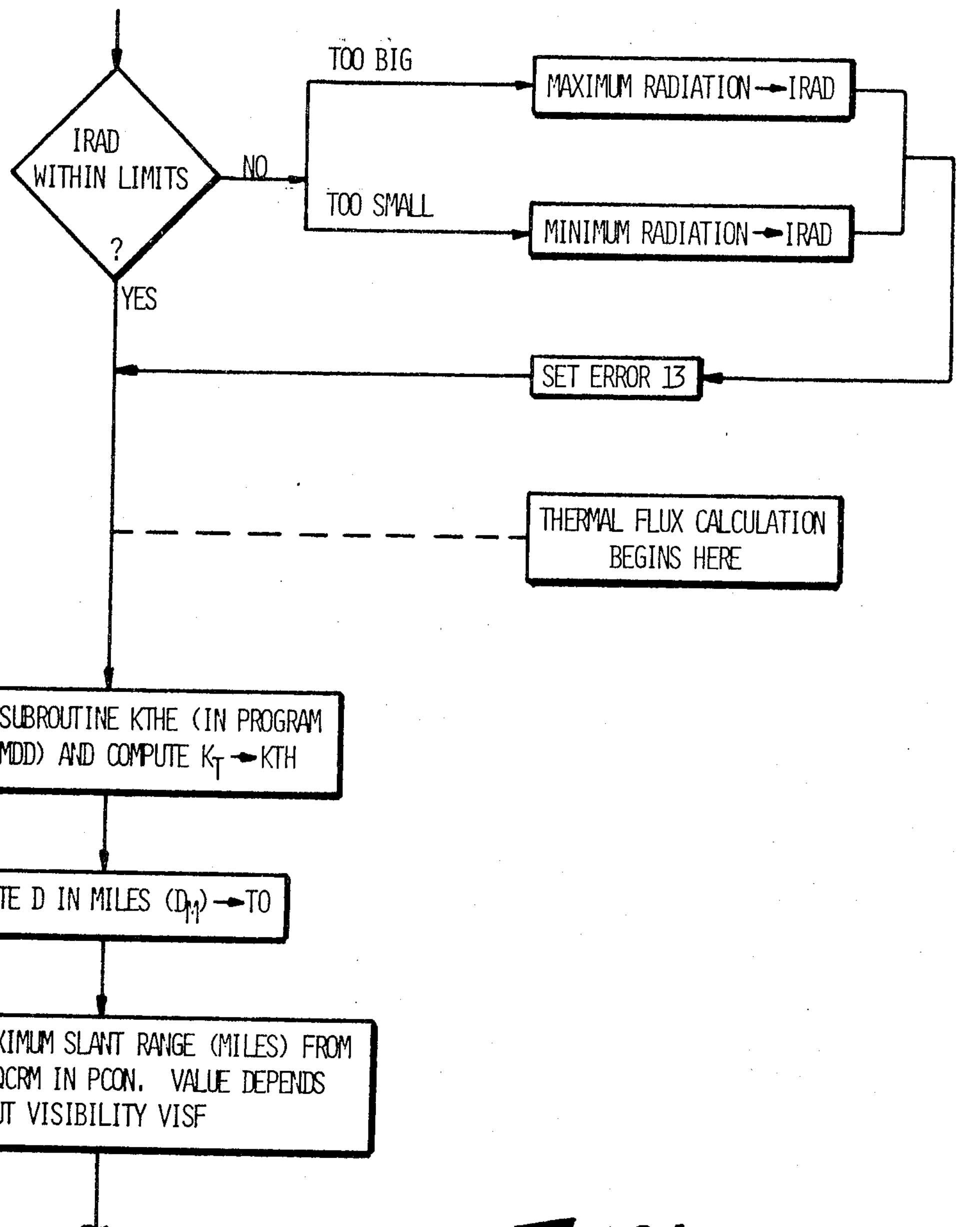

Fig. 19A

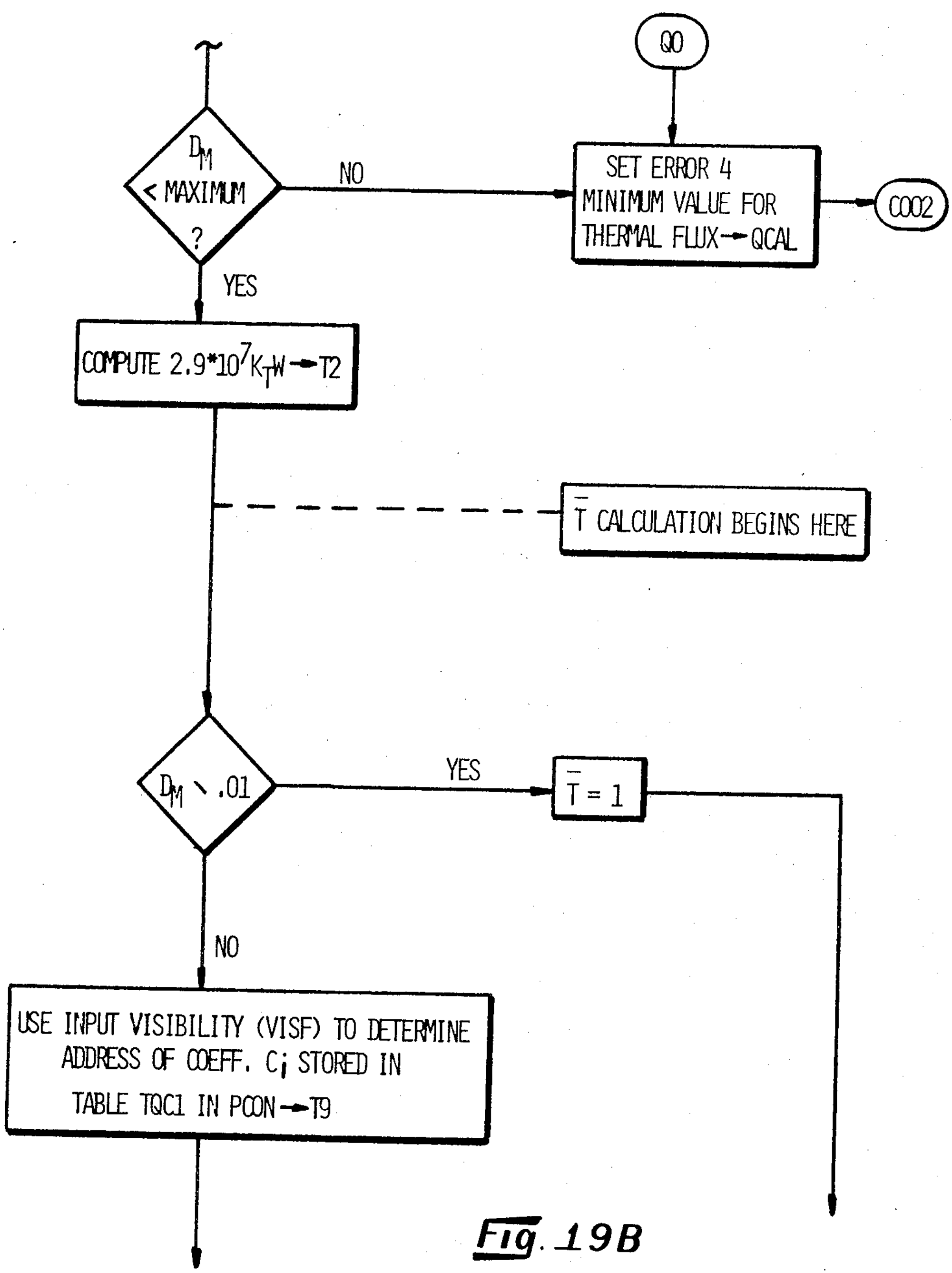
QO
D_M < MAXIMUM ?
NO
SET ERROR 4
MINIMUM VALUE FOR
THERMAL FLUX→QCAL
COO2
YES
COMPUTE 2.9*10^7 K_T W→T2
T̄ CALCULATION BEGINS HERE
D_M ∖ .01
YES
T̄ = 1
NO
USE INPUT VISIBILITY (VISF) TO DETERMINE
ADDRESS OF COEFF. C_i STORED IN
TABLE TQC1 IN PCON→T9

Fig. 19B

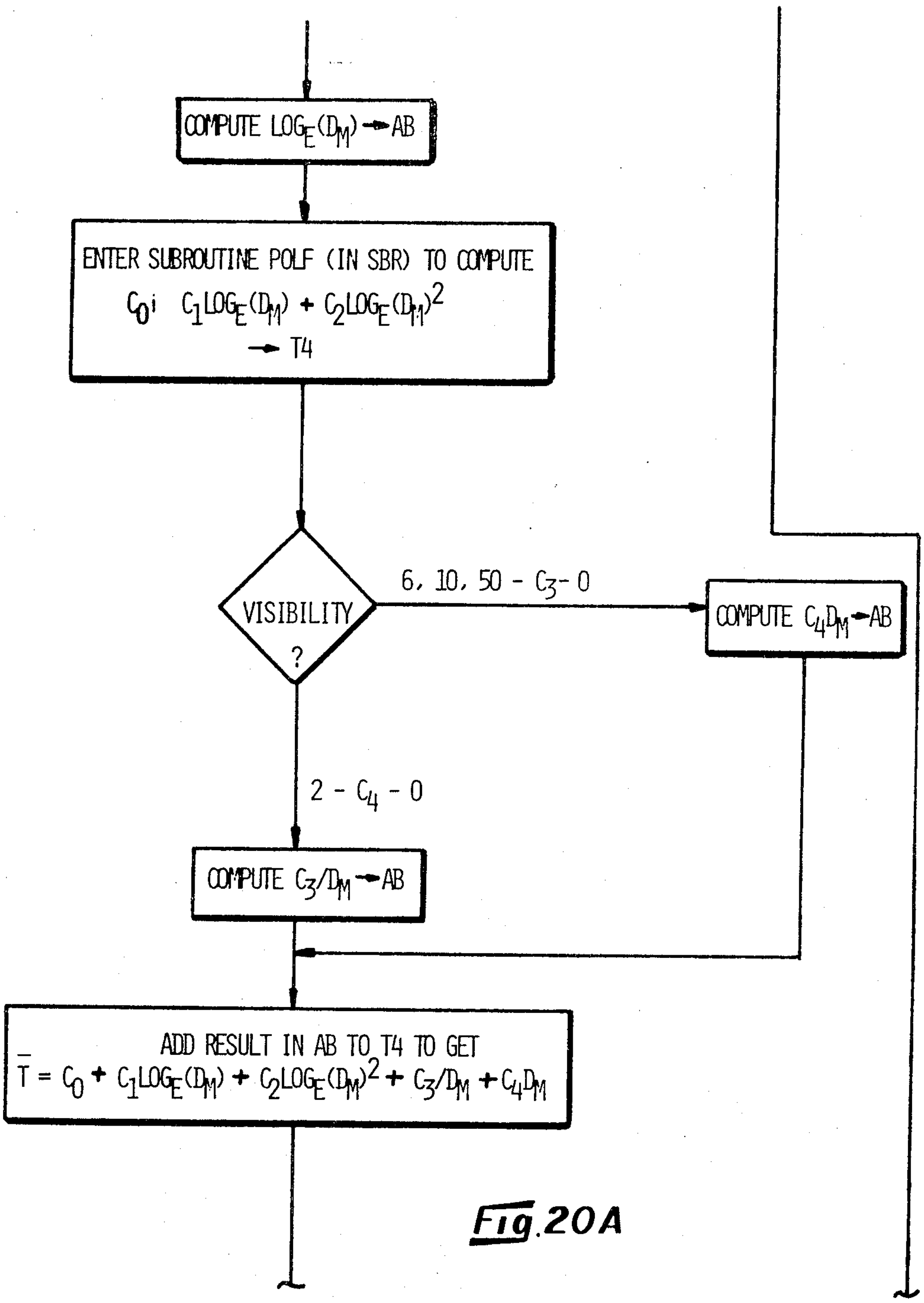
COMPUTE $LOG_E(D_M) \rightarrow AB$
ENTER SUBROUTINE POLF (IN SBR) TO COMPUTE
$C_0 + C_1 LOG_E(D_M) + C_2 LOG_E(D_M)^2 \rightarrow T4$
VISIBILITY ?
6, 10, 50 - C_3 - 0
COMPUTE $C_4 D_M \rightarrow AB$
2 - C_4 - 0
COMPUTE $C_3/D_M \rightarrow AB$
ADD RESULT IN AB TO T4 TO GET
$\bar{T} = C_0 + C_1 LOG_E(D_M) + C_2 LOG_E(D_M)^2 + C_3/D_M + C_4 D_M$

Fig. 20A

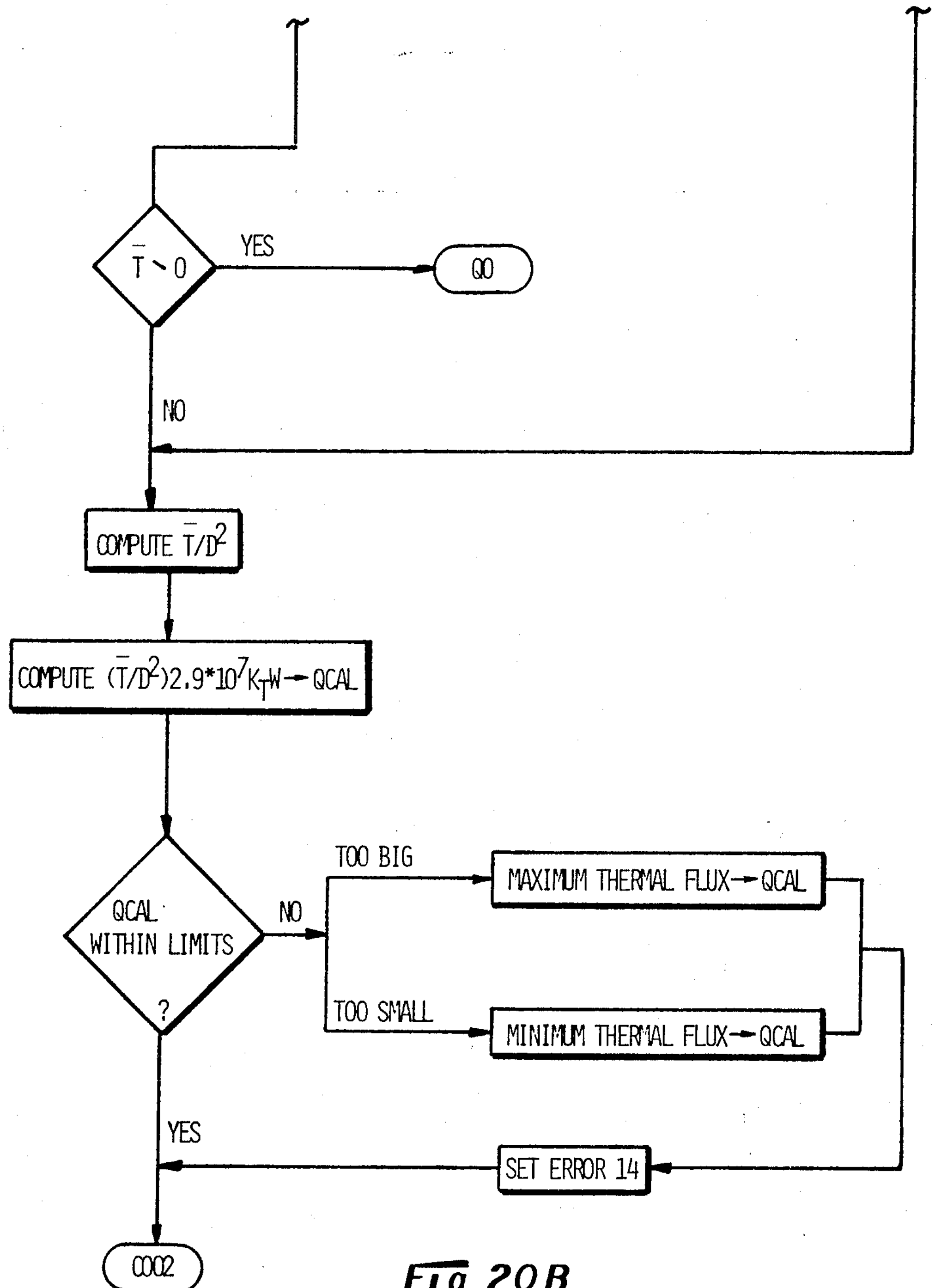
$\bar{T} \sim 0$
YES
Q0
NO
COMPUTE $\bar{T}/D^2$
COMPUTE $(\bar{T}/D^2)2.9*10^7K_TW \to$ QCAL
QCAL WITHIN LIMITS ?
NO
TOO BIG
MAXIMUM THERMAL FLUX → QCAL
TOO SMALL
MINIMUM THERMAL FLUX → QCAL
YES
SET ERROR 14
C002

FIG. 20B

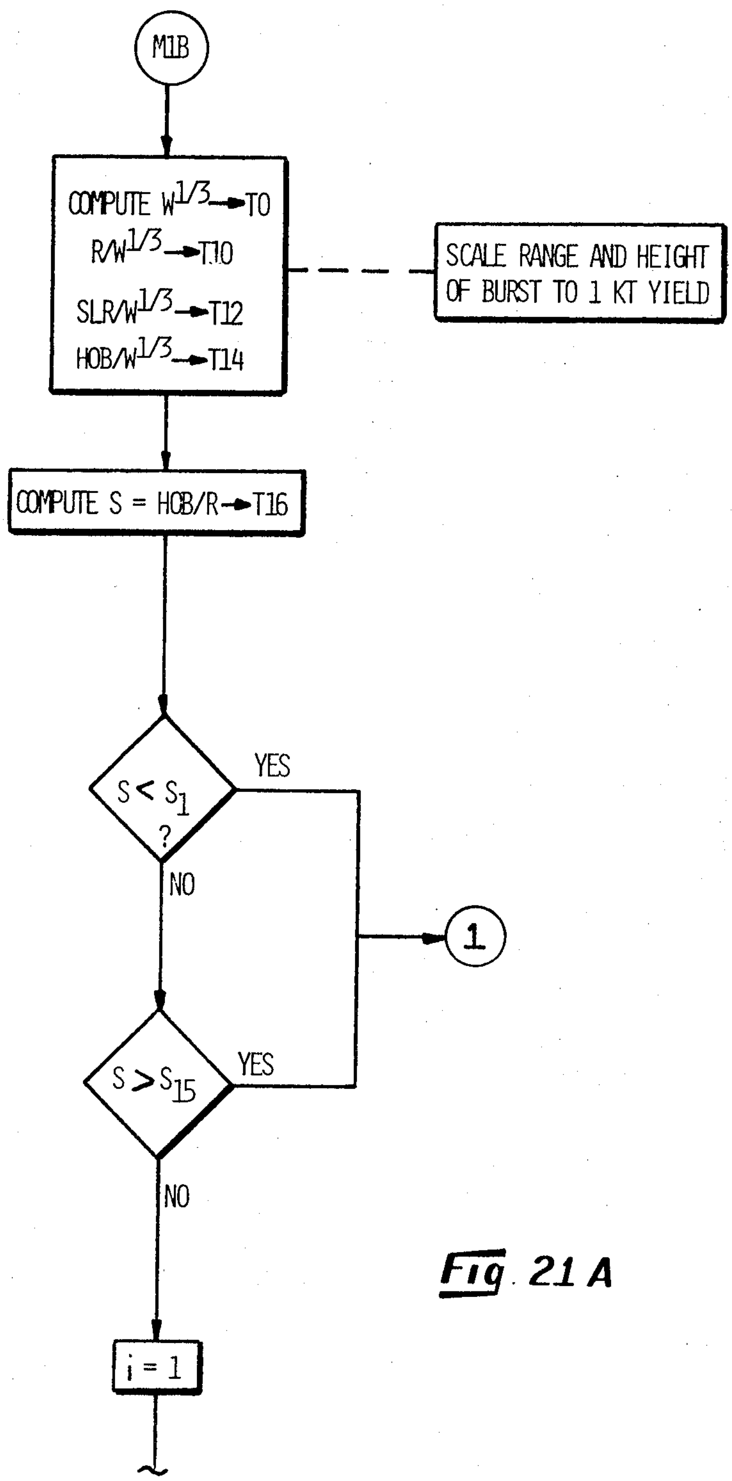
M1B
COMPUTE $W^{1/3} \rightarrow T0$
$R/W^{1/3} \rightarrow T10$
$SLR/W^{1/3} \rightarrow T12$
$HOB/W^{1/3} \rightarrow T14$
SCALE RANGE AND HEIGHT OF BURST TO 1 KT YIELD
COMPUTE $S = HOB/R \rightarrow T16$
$S < S_1$?
YES
NO
1
$S > S_{15}$
YES
NO
$i = 1$

FIG. 21 A

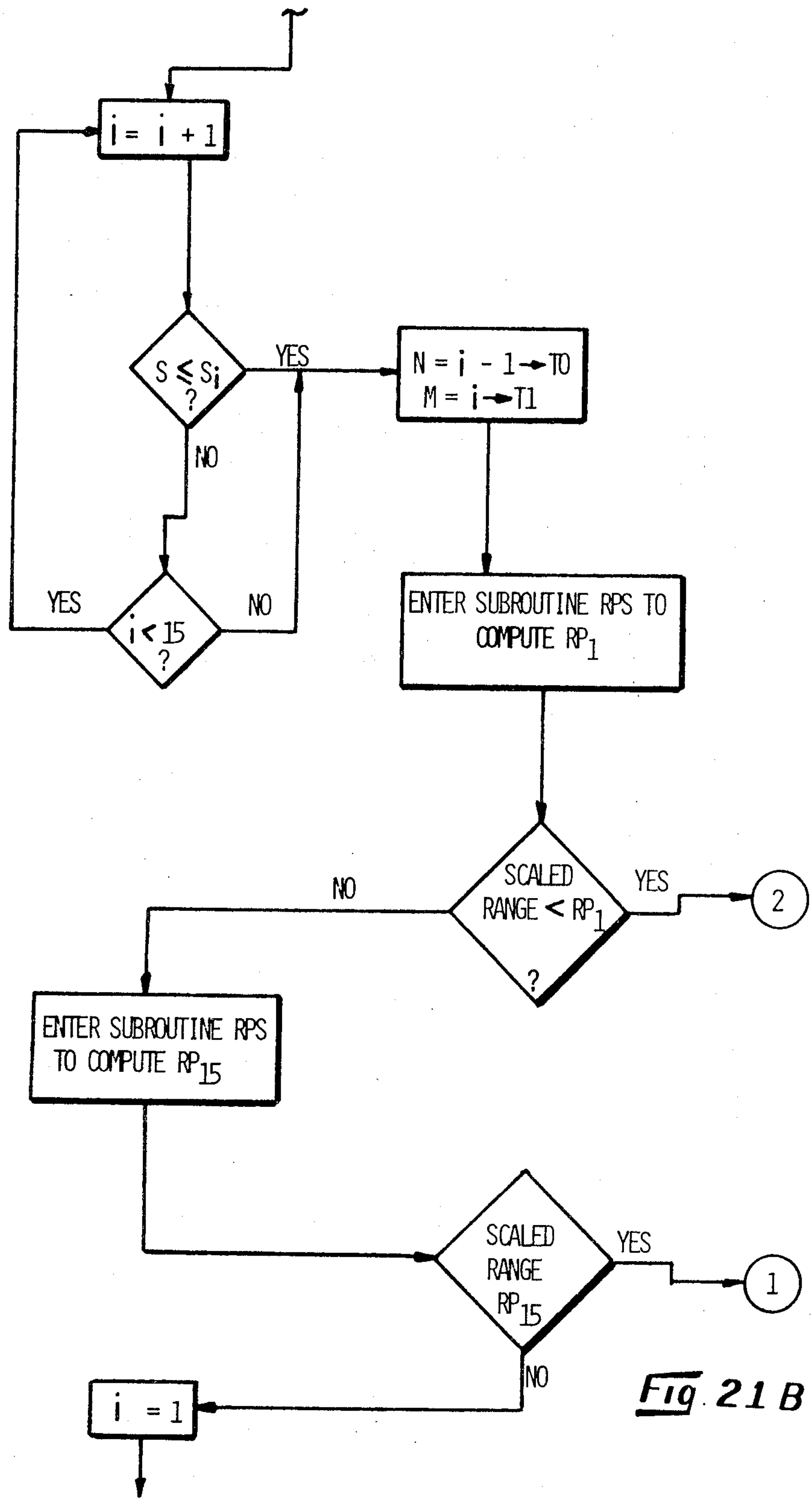
i = i + 1
S ≤ S_i ?
YES
NO
N = i - 1 → T0
M = i → T1
i < 15 ?
YES
NO
ENTER SUBROUTINE RPS TO COMPUTE RP_1
SCALED RANGE < RP_1 ?
NO
YES
2
ENTER SUBROUTINE RPS TO COMPUTE RP_{15}
SCALED RANGE RP_{15}
YES
1
NO
i = 1

Fig. 21 B

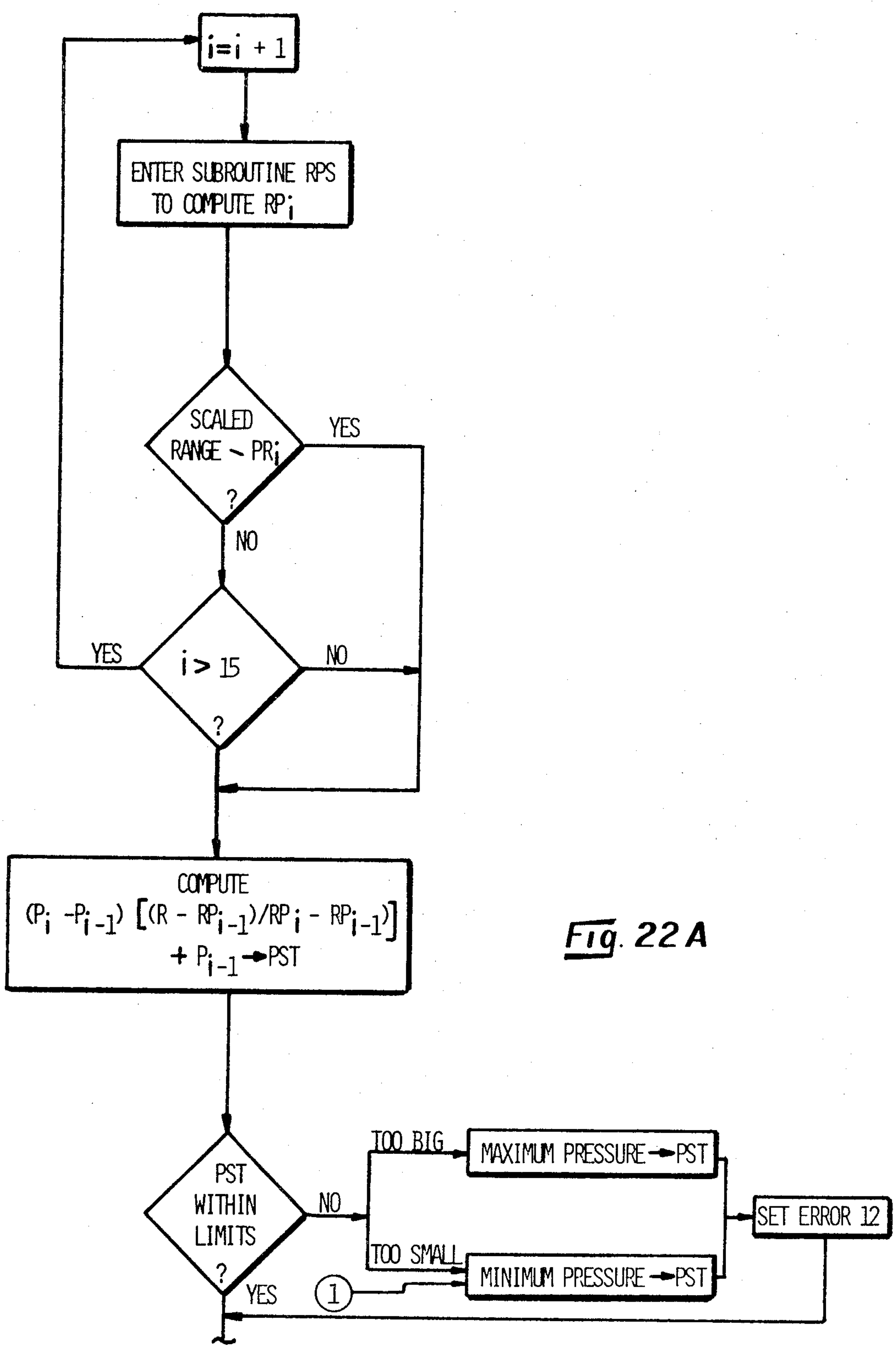
i=i + 1
ENTER SUBROUTINE RPS TO COMPUTE RPi
SCALED RANGE ~ PRi ?
YES
NO
i > 15 ?
YES
NO
COMPUTE
(Pi -Pi-1) [(R - RPi-1)/RPi - RPi-1)] + Pi-1 → PST
PST WITHIN LIMITS ?
NO
YES
TOO BIG
TOO SMALL
MAXIMUM PRESSURE → PST
MINIMUM PRESSURE → PST
SET ERROR 12
1

Fig. 22 A

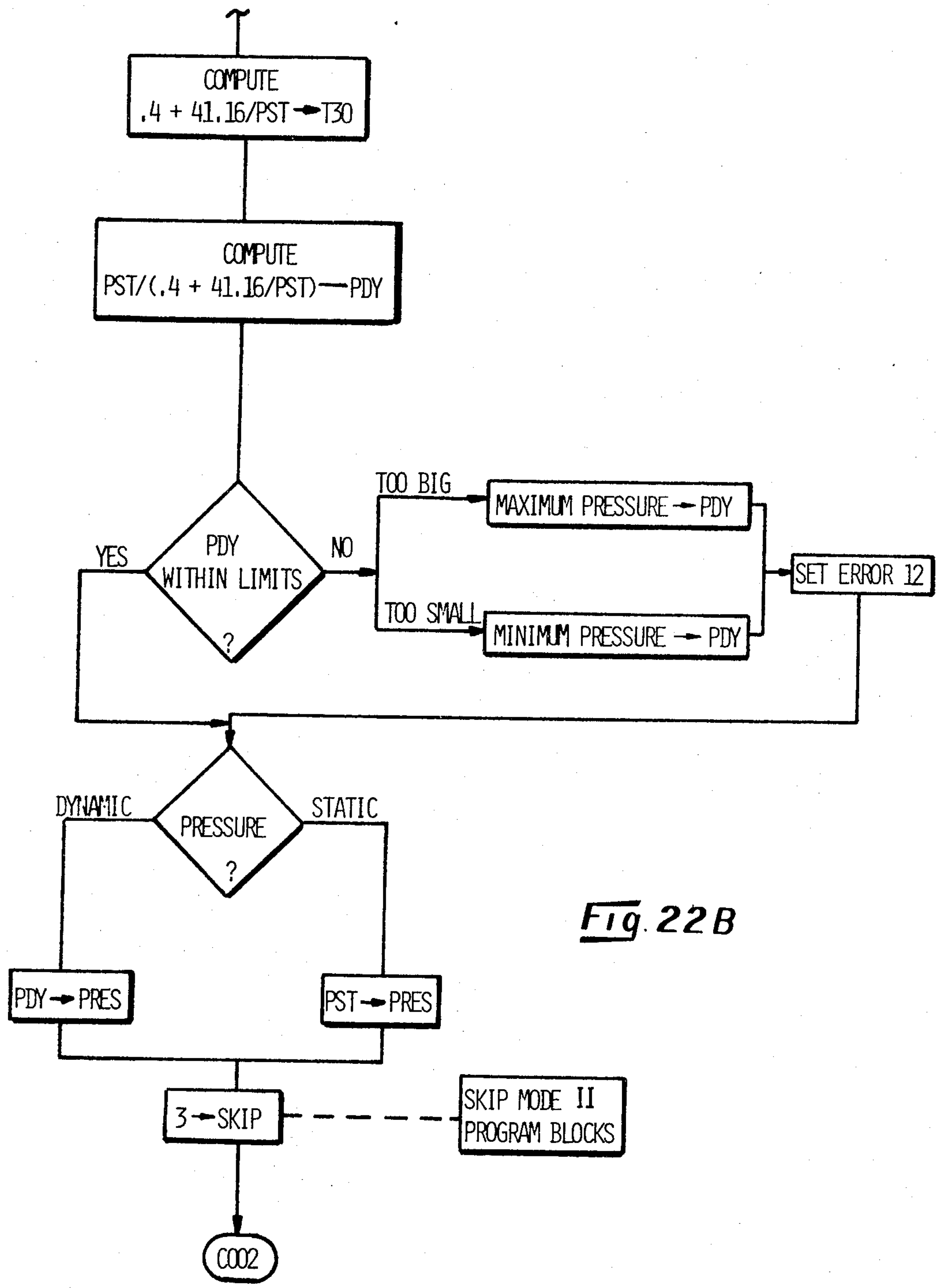
COMPUTE
.4 + 41.16/PST → T30
COMPUTE
PST/(.4 + 41.16/PST) → PDY
PDY
WITHIN LIMITS
?
YES
NO
TOO BIG
MAXIMUM PRESSURE → PDY
TOO SMALL
MINIMUM PRESSURE → PDY
SET ERROR 12
PRESSURE
?
DYNAMIC
STATIC
PDY → PRES
PST → PRES
3 → SKIP
SKIP MODE II
PROGRAM BLOCKS
C002

Fig. 22B

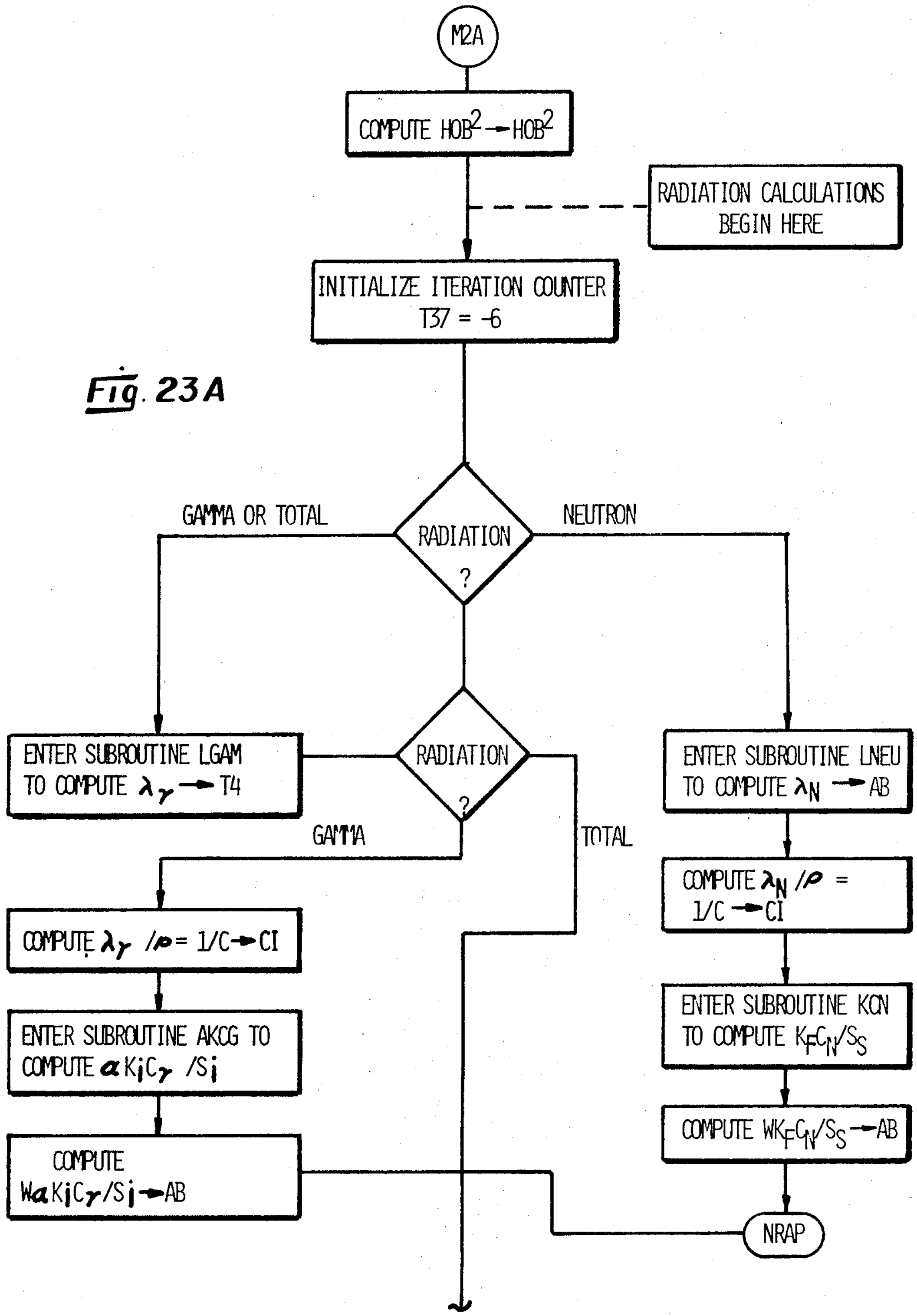
M2A
COMPUTE HOB² → HOB²
RADIATION CALCULATIONS BEGIN HERE
INITIALIZE ITERATION COUNTER T37 = -6
GAMMA OR TOTAL
RADIATION ?
NEUTRON
ENTER SUBROUTINE LGAM TO COMPUTE λγ → T4
RADIATION ?
GAMMA
TOTAL
ENTER SUBROUTINE LNEU TO COMPUTE λN → AB
COMPUTE λγ /ρ = 1/C → CI
COMPUTE λN /ρ = 1/C → CI
ENTER SUBROUTINE AKCG TO COMPUTE αKjCγ /Sj
ENTER SUBROUTINE KCN TO COMPUTE KFCN/SS
COMPUTE WKFCN/SS → AB
COMPUTE WαKjCγ/Sj → AB
NRAP

Fig. 23A

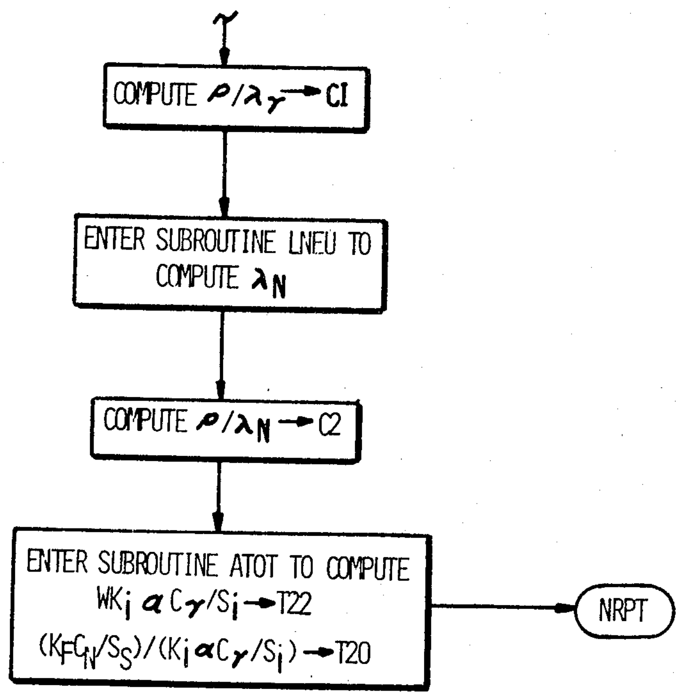
COMPUTE $\rho/\lambda_\gamma \rightarrow$ C1
ENTER SUBROUTINE LNEU TO COMPUTE λ_N
COMPUTE $\rho/\lambda_N \rightarrow$ C2
ENTER SUBROUTINE ATOT TO COMPUTE
$WK_i\ \alpha\ C_\gamma/S_i \rightarrow$ T22
$(K_F C_N/S_S)/(K_i \alpha C_\gamma/S_i) \rightarrow$ T20
NRPT

Fig. 23B

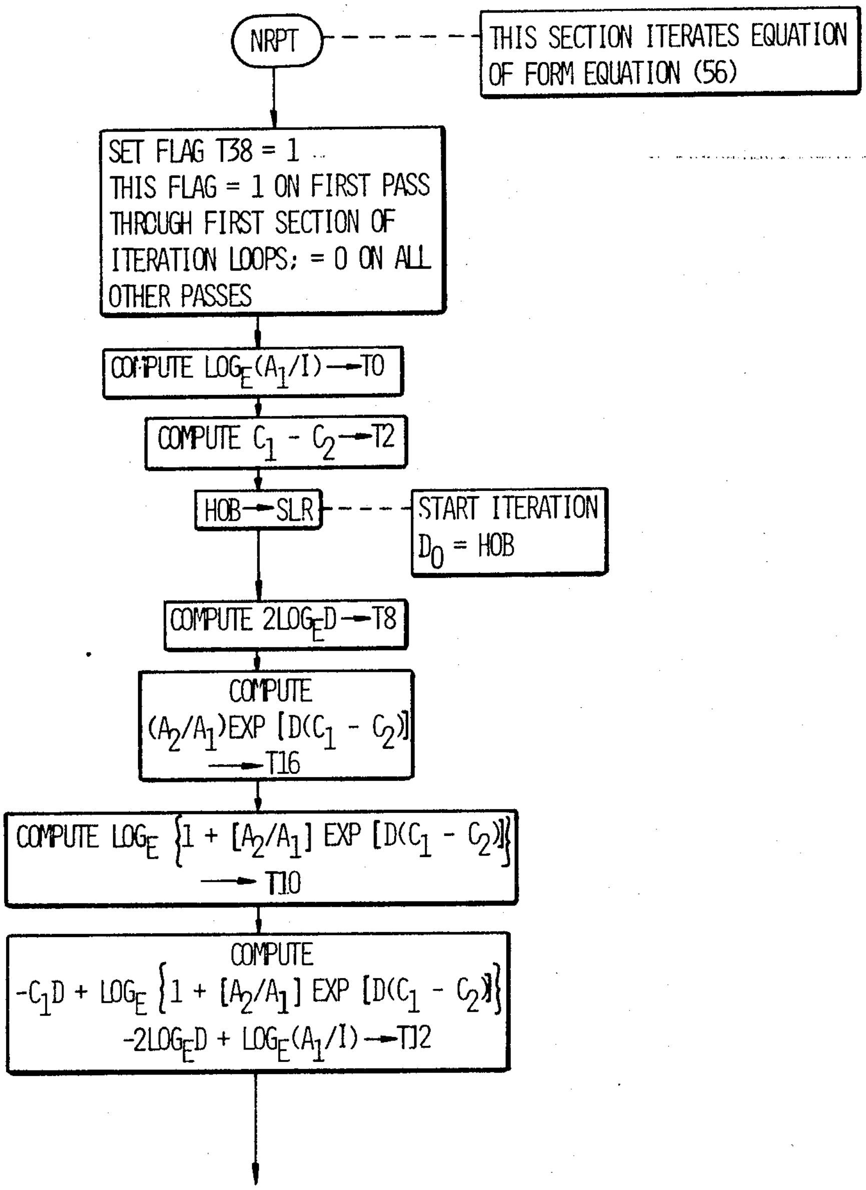
NRPT
THIS SECTION ITERATES EQUATION OF FORM EQUATION (56)
SET FLAG T38 = 1
THIS FLAG = 1 ON FIRST PASS THROUGH FIRST SECTION OF ITERATION LOOPS; = 0 ON ALL OTHER PASSES
COMPUTE $LOG_E(A_1/I) \rightarrow T0$
COMPUTE $C_1 - C_2 \rightarrow T2$
$HOB \rightarrow SLR$
START ITERATION $D_0 = HOB$
COMPUTE $2LOG_E D \rightarrow T8$
COMPUTE $(A_2/A_1)EXP\,[D(C_1 - C_2)] \rightarrow T16$
COMPUTE $LOG_E \{1 + [A_2/A_1]\, EXP\,[D(C_1 - C_2)]\} \rightarrow T10$
COMPUTE $-C_1 D + LOG_E \{1 + [A_2/A_1]\, EXP\,[D(C_1 - C_2)]\} -2LOG_E D + LOG_E(A_1/I) \rightarrow T12$

Fig. 24

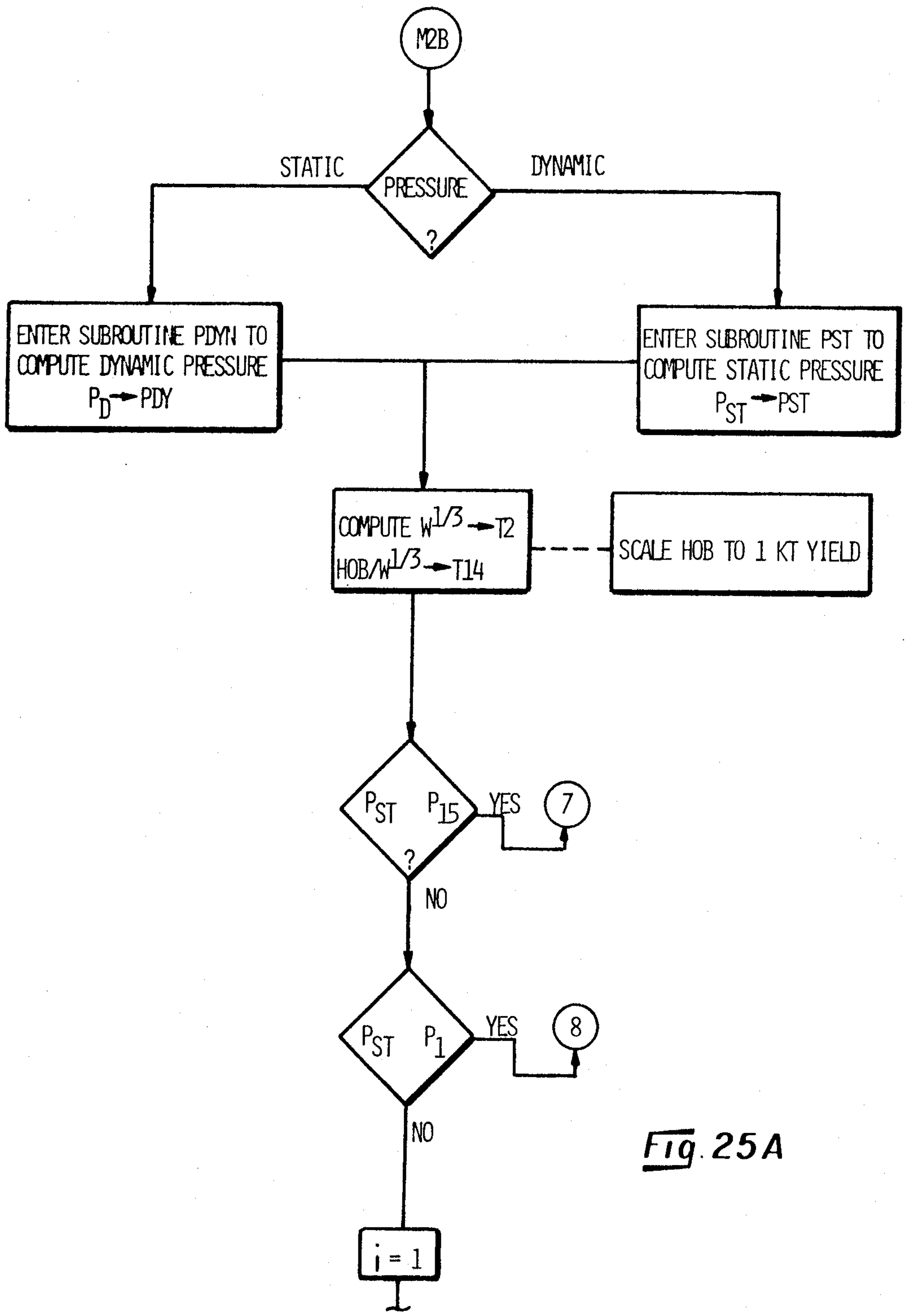
M2B
PRESSURE ?
STATIC
DYNAMIC
ENTER SUBROUTINE PDYN TO COMPUTE DYNAMIC PRESSURE $P_D \rightarrow PDY$
ENTER SUBROUTINE PST TO COMPUTE STATIC PRESSURE $P_{ST} \rightarrow PST$
COMPUTE $W^{1/3} \rightarrow T2$
$HOB/W^{1/3} \rightarrow T14$
SCALE HOB TO 1 KT YIELD
P_{ST} P_{15} ?
YES
7
NO
P_{ST} P_1
YES
8
NO
i = 1

Fig. 25A

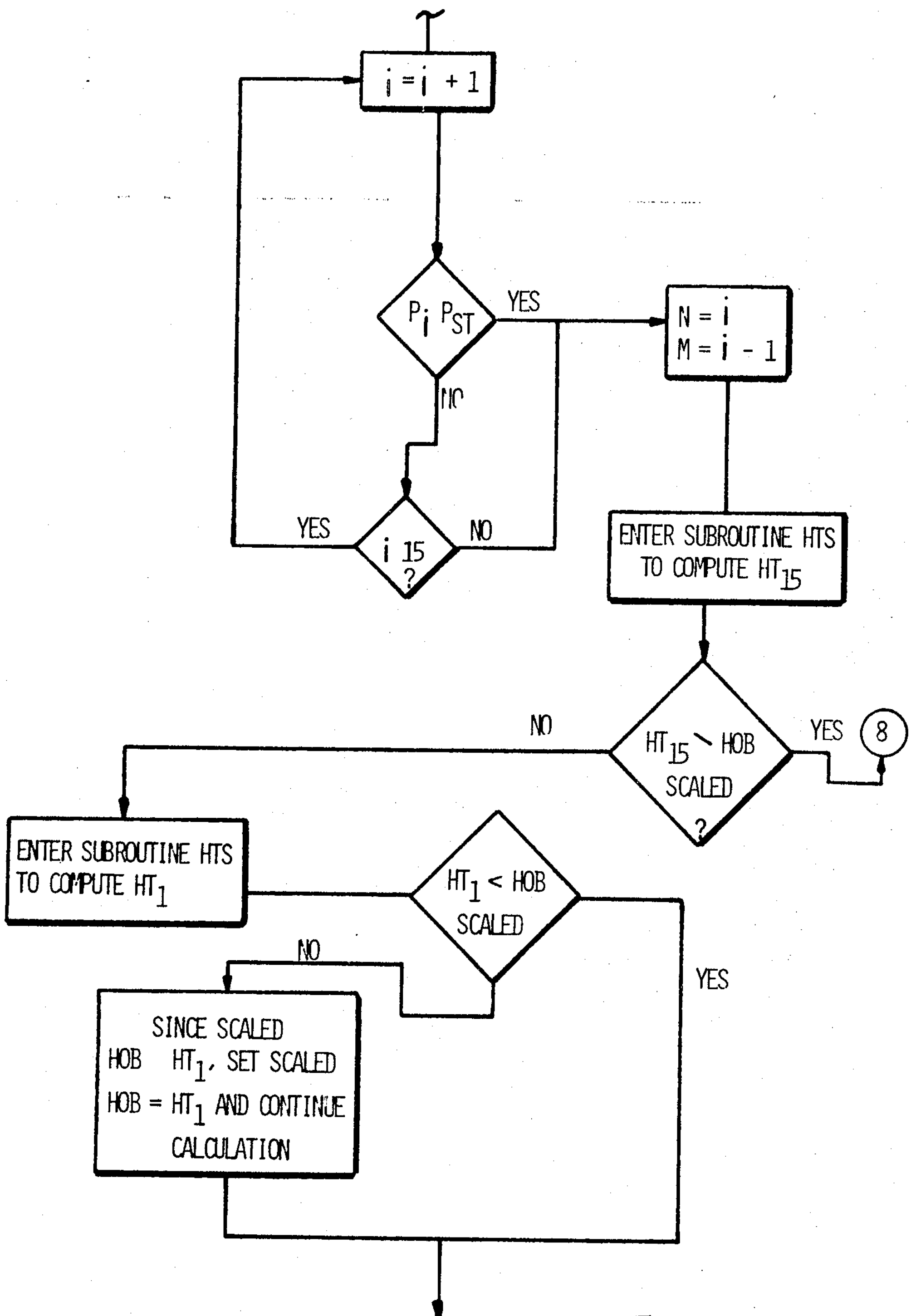
i = i + 1
P_i P_{ST}
YES
NO
N = i
M = i - 1
YES
i 15
?
NO
ENTER SUBROUTINE HTS
TO COMPUTE HT_{15}
NO
HT_{15} HOB
SCALED
?
YES
8
ENTER SUBROUTINE HTS
TO COMPUTE HT_1
HT_1 < HOB
SCALED
NO
YES
SINCE SCALED
HOB HT_1, SET SCALED
HOB = HT_1 AND CONTINUE
CALCULATION

Fig. 25 B

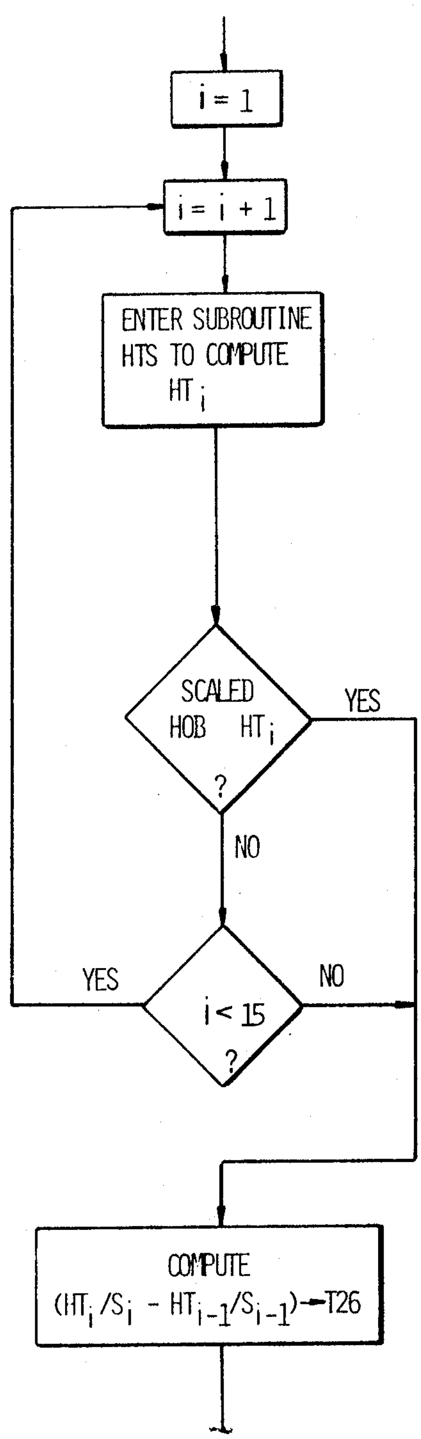
i = 1
i = i + 1
ENTER SUBROUTINE HTS TO COMPUTE HT$_i$
SCALED HOB HT$_i$?
YES
NO
i < 15 ?
YES
NO
COMPUTE (HT$_i$/S$_i$ - HT$_{i-1}$/S$_{i-1}$)→T26

Fig. 26 A

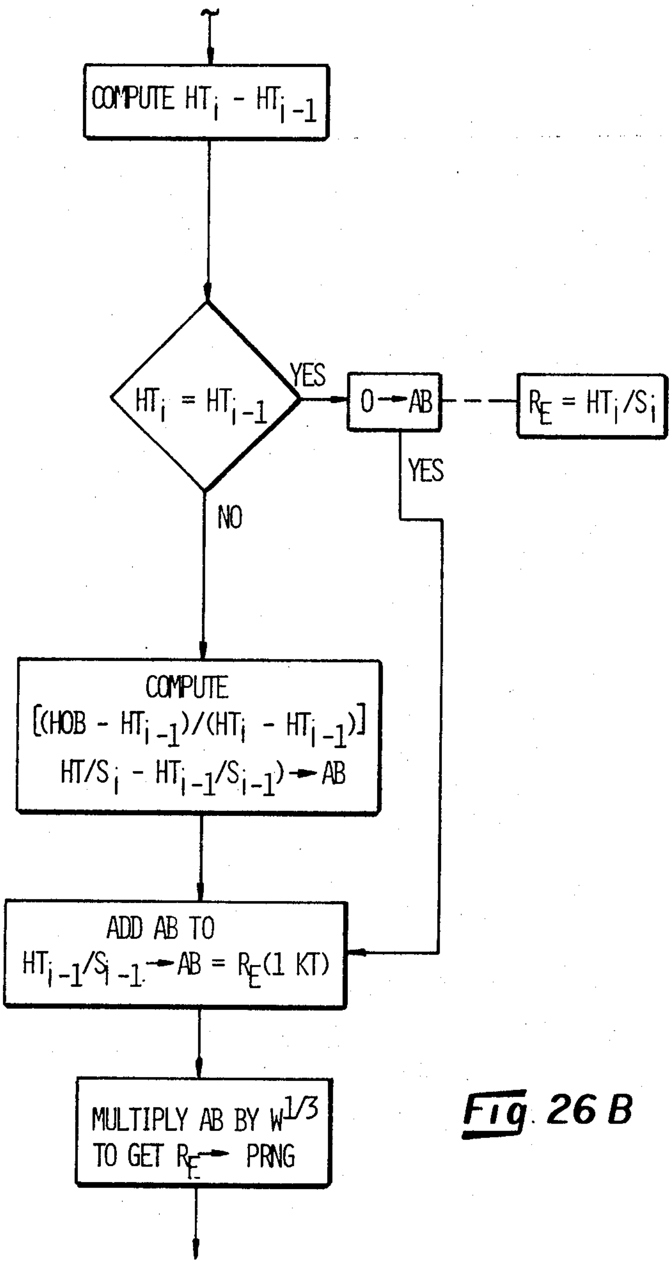
COMPUTE HT$_i$ - HT$_{i-1}$
HT$_i$ = HT$_{i-1}$
YES
0→AB
R$_E$ = HT$_i$/S$_i$
YES
NO
COMPUTE
[(HOB - HT$_{i-1}$)/(HT$_i$ - HT$_{i-1}$)]
HT/S$_i$ - HT$_{i-1}$/S$_{i-1}$)→AB
ADD AB TO
HT$_{i-1}$/S$_{i-1}$→AB = R$_E$(1 KT)
MULTIPLY AB BY W$^{1/3}$
TO GET R$_E$→ PRNG

Fig. 26 B

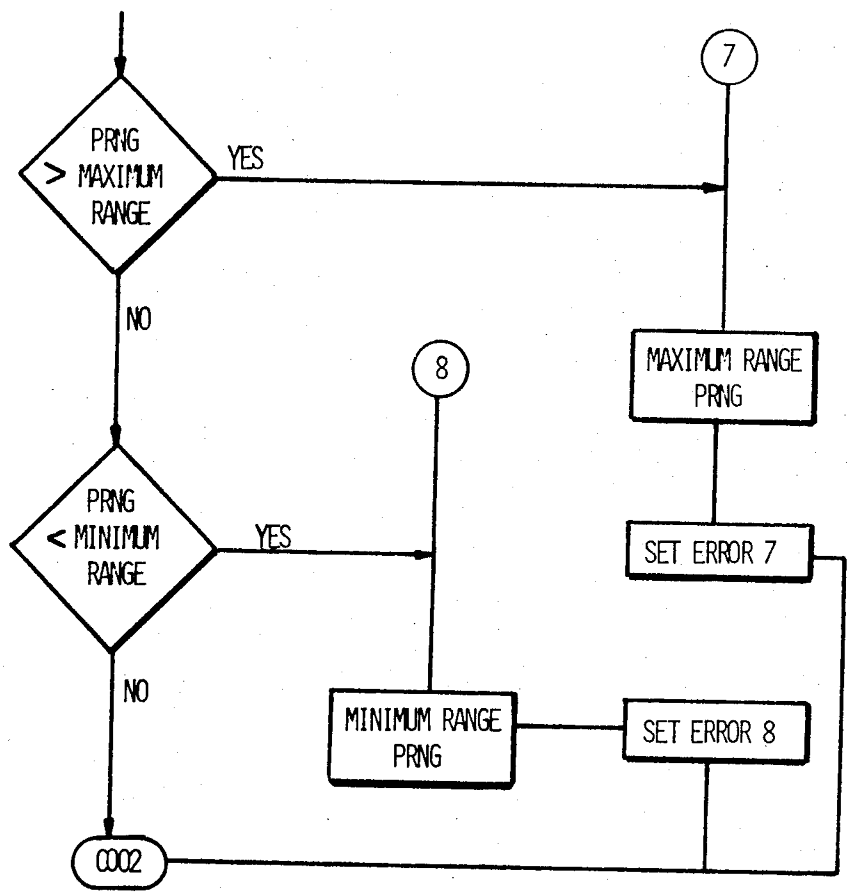
PRNG
> MAXIMUM
RANGE
YES
NO
7
8
MAXIMUM RANGE
PRNG
PRNG
< MINIMUM
RANGE
YES
SET ERROR 7
NO
MINIMUM RANGE
PRNG
SET ERROR 8
C002

FIG. 27A

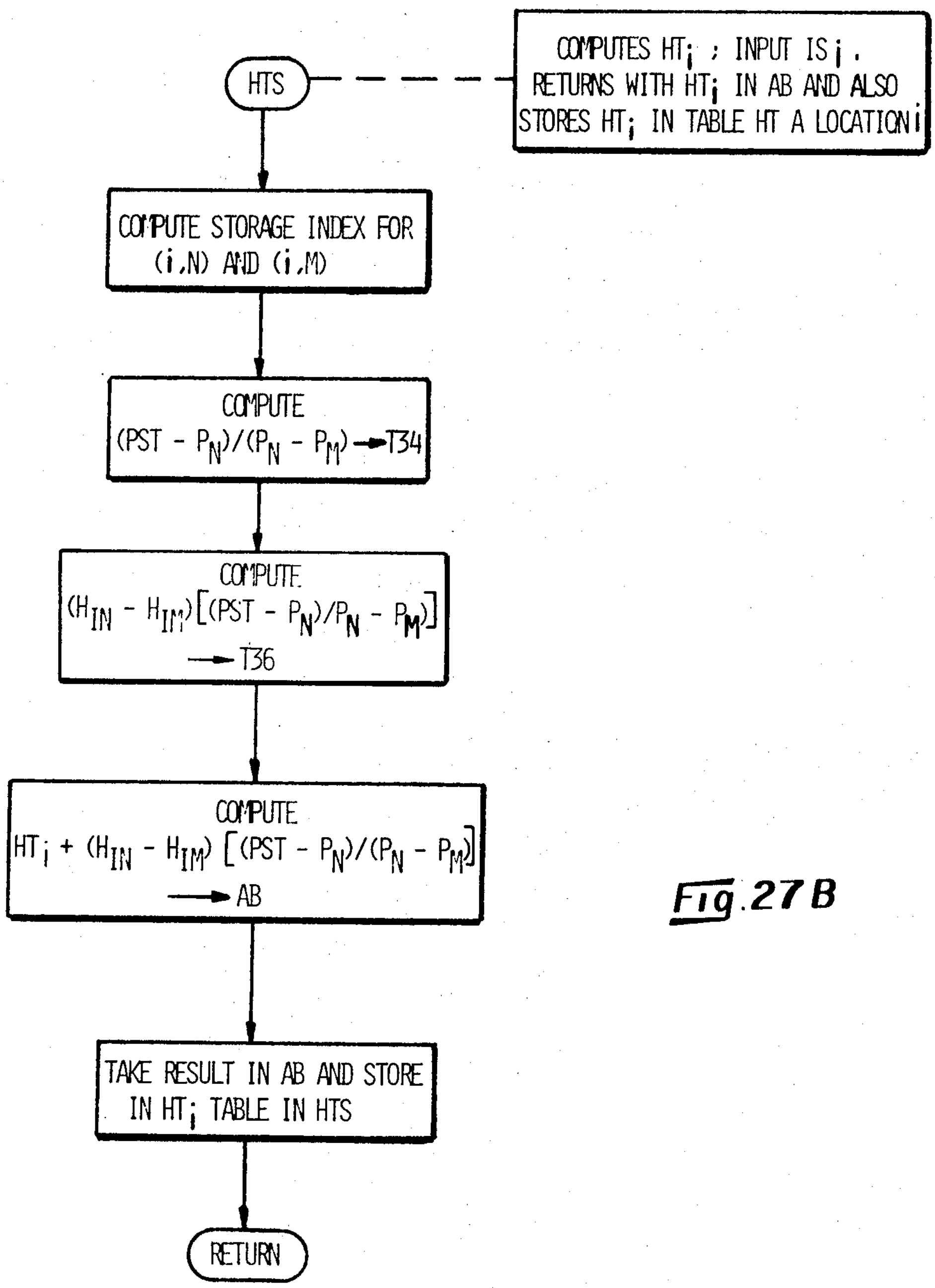
HTS
COMPUTES HT_i ; INPUT IS i. RETURNS WITH HT_i IN AB AND ALSO STORES HT_i IN TABLE HT A LOCATION i
COMPUTE STORAGE INDEX FOR (i,N) AND (i,M)
COMPUTE $(PST - P_N)/(P_N - P_M) \rightarrow T34$
COMPUTE $(H_{IN} - H_{IM})[(PST - P_N)/P_N - P_M)] \rightarrow T36$
COMPUTE $HT_i + (H_{IN} - H_{IM})[(PST - P_N)/(P_N - P_M)] \rightarrow AB$
TAKE RESULT IN AB AND STORE IN HT_i TABLE IN HTS
RETURN

Fig. 27B

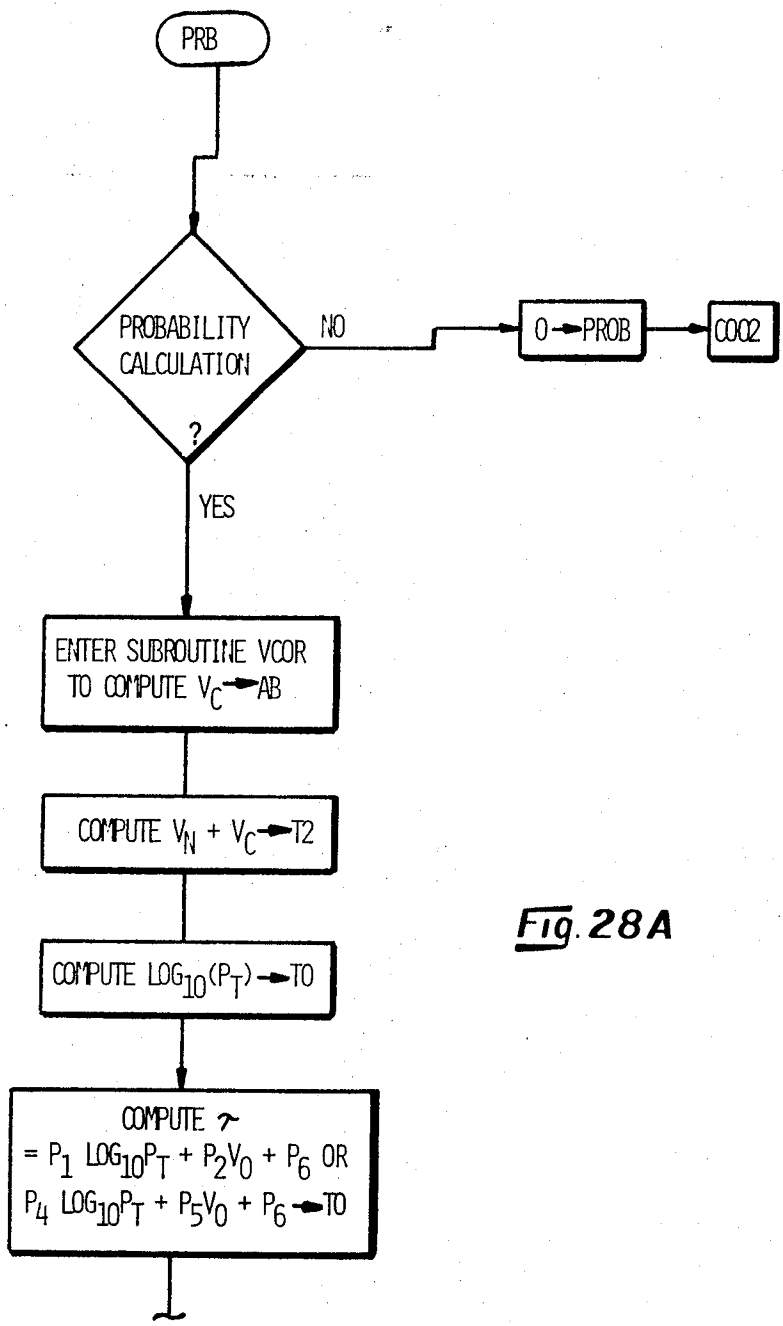
PRB
PROBABILITY CALCULATION ?
NO
0 → PROB
C002
YES
ENTER SUBROUTINE VCOR TO COMPUTE V_C → AB
COMPUTE $V_N + V_C$ → T2
COMPUTE $LOG_{10}(P_T)$ → T0
COMPUTE $\tau = P_1\ LOG_{10}P_T + P_2V_0 + P_6$ OR $P_4\ LOG_{10}P_T + P_5V_0 + P_6$ → T0

Fig. 28A

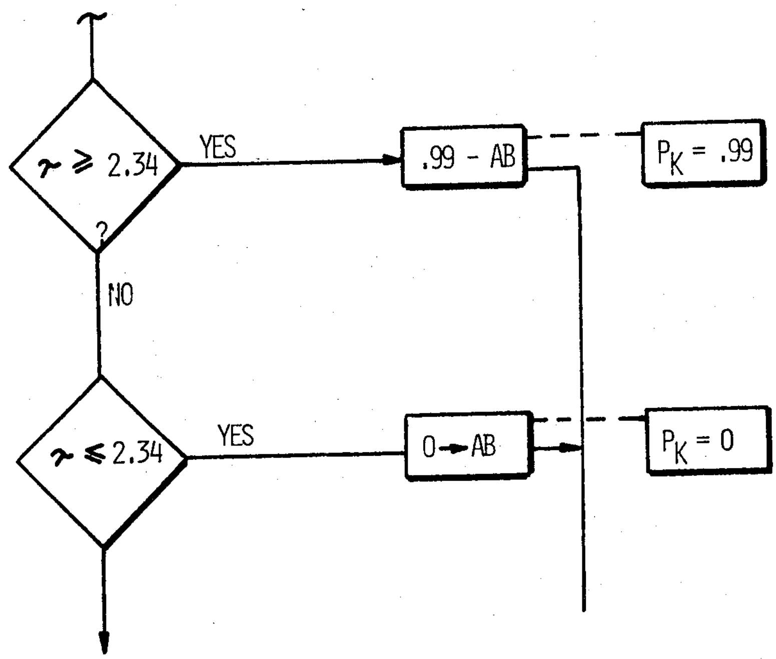
$\tau \geq 2.34$
?
YES
NO
.99 - AB
$P_K = .99$
$\tau \leq 2.34$
YES
$0 \rightarrow AB$
$P_K = 0$

Fig. 28B

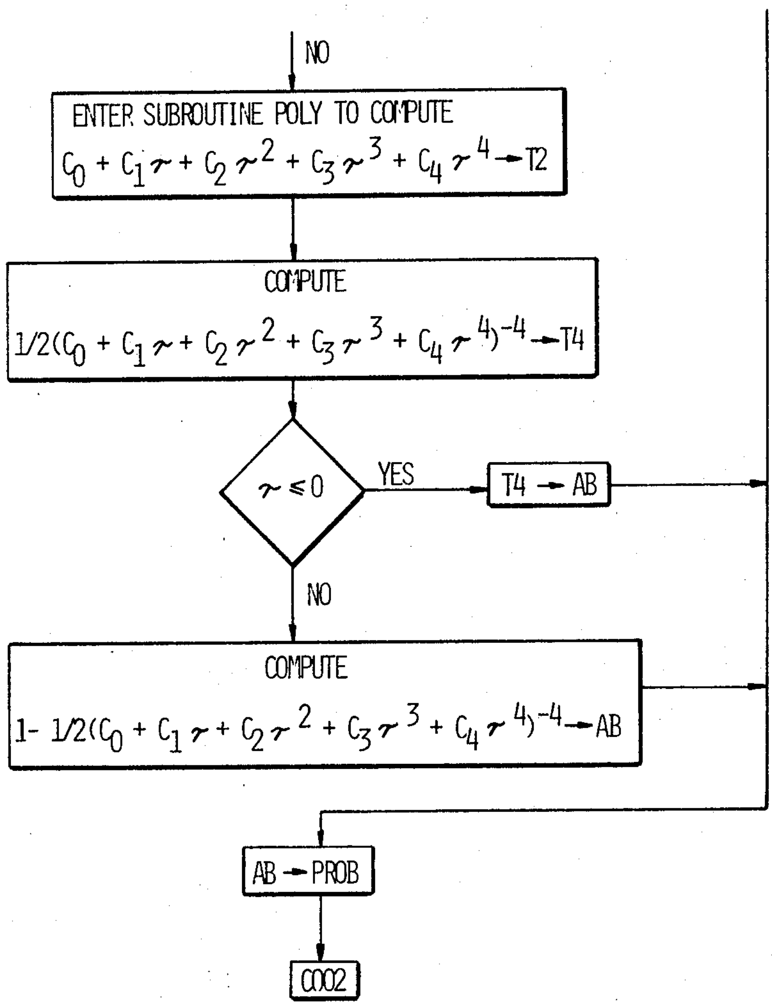
NO
ENTER SUBROUTINE POLY TO COMPUTE
$C_0 + C_1\tau + C_2\tau^2 + C_3\tau^3 + C_4\tau^4 \rightarrow T2$
COMPUTE
$1/2(C_0 + C_1\tau + C_2\tau^2 + C_3\tau^3 + C_4\tau^4)^{-4} \rightarrow T4$
$\tau \leq 0$
YES
$T4 \rightarrow AB$
NO
COMPUTE
$1 - 1/2(C_0 + C_1\tau + C_2\tau^2 + C_3\tau^3 + C_4\tau^4)^{-4} \rightarrow AB$
$AB \rightarrow PROB$
C002

Fig. 29

GRAPHICS DISPLAY SYSTEM

RELATED APPLICATION

This application is a continuation-in-part of application Ser. No. 816,349, GRAPHICS DISPLAY SYSTEM, filed Apr. 15, 1969, in the name of the inventor, Carl W. Berndt, now abandoned.

BACKGROUND OF THE INVENTION

The invention described herein was made in the course of, or under Contract No. W-7405-ENG-48, with the United States Atomic Energy Commission.

The invention relates to automated display systems, particularly to a system for displaying effects of nuclear explosions, and more particularly to a system for computing and displaying prompt and delayed effects of nuclear explosions with respect to a geographical area.

The event of a nuclear detonation is characterized by certain destructive effects, the accurate assessment and prediction of which is the key to intelligent use and prudent counter measures. The total destructive result is generally a combination of primary and secondary effects, the three primary "effects" being direct radiation, blast and thermal; while the secondary "effect" is radioactive fallout. In the order of their incidence at any location, the first of these primary "effects" is radiation emitted directly as a result of the explosion, such radiation being electromagnetic, e.g., gamma rays, and particle; e.g., neutron flux. The secondary primary "effect," blast, is characterized by a shockwave and a general increase in the atmospheric pressure surrounding the detonated device, both spreading spherically from the point of detonation. The third primary "effect," thermal flux, is propagated through the surrounding atmosphere, and consisting of intense longwave radiation and extremely high temperature gases. The secondary "effect," radioactive fallout, consists of radioactive materials produced in the device itself, as well as by irradiation of natural materials at the detonation site. The magnitude of each of these "effects," both primary and secondary, is essentially determined by the type and nature of the nuclear device, and by the environmental conditions at the time and place of detonation, and in the case of fallout, the atmospheric conditions subsequent to the detonation. The primary "effects" generally exhibit characteristic propagation patterns which may be predetermined and organized into useful relationships, while the secondary "effect" is more volatile, strongly depending on meteorological conditions, such as wind direction, etc. Thus, the geographical location at which the "effects" occur will produce variations in the total destructive result of the nuclear detonation.

The specific parameters upon which the magnitude of the "effects" at any point depends are, first, those which are device-related. The most useful quality is the yield of the device which is generally given in terms of an equivalent weight of chemical explosive TNT. Also, the type of nuclear device, e.g., fission or fusion, is a significant characteristic. A third factor concerns the height above ground at which the device is detonated. For example, the propagation of direct radiation is sharply attenuated for devices detonated close to the earth's surface, as compared to deployment at an altitude of several hundred feet. Other influential factors include environmental conditions, such as air density, visibility, wind direction and wind velocity, which affect the propagation of the "effects" through the intervening atmosphere; radiation shielding factors, which measure the susceptibility of particular targets to radiation; and vulnerability factors which indicate the relative immunity of certain targets to blast pressures.

Through empirical and analytical studies, the art has developed functional relationships which allow for calculation of a magnitude for each of the above primary "effects" at any desired point distal a detonated device. Commonly, these primary "effects" are derived by calculating each individual "effect" as a function of ground range for series of incremental values of the data parameters and placed in tabular form as a reference source. The employment of these reference tables is unsatisfactory where a rapid assessment of the overall "effects" and the geographical distribution thereof is required. Furthermore, the possibility of tracking some of the "effects," particularly radioactive fallout, become improbable because the unfolding of these "effects" requires laborious computations beyond the skills and knowledge of the layman, and too time consuming for the expert.

A system for automatically calculating solutions to a plurality of functions for the primary or prompt "effects" of a nuclear detonation, and graphically displaying these solutions simultaneously on a common background chart is disclosed and claimed in U.S. Pat. No. 3,558,865, issued Jan. 26, 1971, entitled, "Weapons Effect Display System," assigned to the same assignee and with the inventor of the present application being a coinventor in this previous patent. However, this prior system does not provide for computing and displaying the delayed or secondary "effect," radioactive fallout.

SUMMARY OF THE INVENTION

With the advent of computer graphics, it is now possible to track some of the complicated effects which might occur after the detonation of a nuclear explosive. The computer graphics display of the present invention instantaneously computes and shows the "effects," both primary and secondary, in meaningful, graphical representation for use by researcher and layman, particularly military and civil defense personnel in understanding, analyzing, demonstrating and predicting the effects of nuclear weapons. The system provides a superposition of prompt or primary "effects," i.e., direct radiation, blast and thermal, represented by concentric circles; secondary "effect," i.e., fallout, represented by a time varying growing and variegated moasic pattern; and a map or a geographical area whose scale is controllable upon command, and includes a computer which controls the display and makes changes on it, utilizing relationships which characterize nuclear effects as functions of time.

The present invention differs from the above referenced patent in the utilization or modification of a digital computer, disk memory, logic interface, control panel, numerical readouts, and a CRT for displaying the fallout pattern. The primary difference in the present invention and the above mentioned patent being the present use of a compact, programmable digital computer which displays fallout as a function of time, together with the prompt "effects" and the map, while in the prior patent only the prompt "effects" and map were displayed and controlled by a non-programmable analog computer. Thus, the present invention provides

a considerably modified and improved system over that disclosed in said prior patent.

Therefore, it is an object of the invention to provide a system for computing and displaying prompt and delayed effects of nuclear explosions with respect to a geographical area.

A further object of the invention is to provide a graphic display system which provides a time-varying display of fallout, as well as prompt effects superimposed upon a map, while minimizing the time interval between feeding the input parameters into the system and the appearance of the display.

Another object of the invention is to provide a system for computing and displaying nuclear weapons effects, both primary and secondary, to enable more accurate assessment and prediction of the destructive effects of a nuclear detonation.

Other objects of the invention will become readily apparent from the following description and accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a block schematic of the inventive computing and display system;

FIG. 2 is a view of a "keyhole" fallout pattern produced by the FIG. 1 system;

FIG. 3 is a view of a typical fallout pattern at a time period after detonation as produced by the FIG. 1 system;

FIG. 4 is a schematic of the control panel and numerical display;

FIG. 5 is a functional block diagram of the prompt effects circle logic;

FIG. 6 is a functional block diagram of the fallout display system control logic.

FIG. 7 is a functional block diagram of the Read Only Memory of FIG. 5.

FIG. 8A–8B is a diagram showing the layout of the core memory of the digital computer of FIG. 1 for the Fallout System.

FIG. 9 is a diagram showing the core layout of the digital computer of FIG. 1 for fallout load functions.

FIG. 10 is a flowchart for a programming sequence.

FIG. 11A–11B is a continuation of the flowchart of FIG. 10.

FIG. 12A–12B is a flowchart for a programming sequence.

FIG. 13A–13B is a continuation of the flowchart of FIG. 12.

FIG. 14A–14B is a continuation of the flowchart of FIG. 13.

FIG. 15A–15B is a flowchart for a programming sequence.

FIG. 16 is a flowchart for a programming sequence.

FIG. 17 is a continuation of the flowchart of FIG. 16.

FIG. 18A–18B is a flowchart for a programming sequence.

FIG. 19A–19B is a continuation of the flowchart of FIG. 18.

FIG. 20A–20B is a continuation of the flowchart of FIG. 19.

FIG. 21A–21B is a flowchart for a programming sequence.

FIG. 22A–22B is a continuation of the flowchart of FIG. 21.

FIG. 23A–23B is a flowchart for a programming sequence.

FIG. 24 is a flowchart for a programming sequence.

FIG. 25A–25B is a flowchart for a programming sequence.

FIG. 26A–26B is a continuation of the flowchart of FIG. 25.

FIG. 27A–27B is a continuation of the flowchart of FIG. 26.

FIG. 28A–28B is a flowchart for a programming sequence.

FIG. 29 is a continuation of the flowchart of FIG. 28.

DESCRIPTION OF THE INVENTION

Large computer facilities and extensive programs for handling fallout problems are available in the prior art. However, the inventive system described hereinafter, and the logic design and software package for driving the system components, is aimed at minimizing turnaround time, i.e., the time interval between feeding the input parameters into the system and the appearance of the display.

In functional terms, a specific feature of the software designed for the inventive system is the easy access to the fallout program. This is provided by an interface logic capable of furnishing a display of fallout as it appears over an area (1) after a desired period of time, or (2) as a repetitive time-varying display of the expanding fallout pattern under the influence of conditions existing at the time of detonation. In the latter mode, the logic is also accessible to the operator during the course of the calculation. Additional inputs are provided for adding data which will change the output to also reflect the influence of time-varying parameters. In the display projected onto the screen, this feature allows the prediction and portrayal of the nature of fallout patterns produced by changing meteorological conditions. This is important, since wind conditions, for example, cannot be assumed to remain constant throughout the course of the relatively long term fallout expansion and precipitation process after detonation.

In addition, the inventive system provides two modes of operation, termed Function A and Function B. The former mode is for comparing the hereinafter described system to an existing military system for rough fallout prediction. The latter mode is a more general and accurate display of the present system computer output. Both modes A and B can be simultaneously displayed for evaluation upon proper actuation of the input controls, if desired.

Prior to the description of the FIG. 1 system, the inventive system utilizes three separate images simultaneously projected on a screen from three separate sources, each of which is described in turn hereinbelow.

The first or upper image, as illustrated, is that of a map or aerial photograph projected from a slide projector or other projection apparatus. The image arrives at the screen through a system of mirrors if direct projection is not possible. The projector may vary the scale of the image upon receipt of an appropriate signal at the command of the operator. The maps or aerial photographs may be of various sections of the country or other areas of interest to the military, civil defense, or others.

The second or middle image, as shown, is derived from a projection cathode ray tube (CRT), an output medium for a digital computer of the disclosed system. The computer receives analog inputs from the operator

who defines the initial conditions under which a nuclear explosive is detonated. A simple analog input means such as dials will initially set the aforementioned conditions, while a "joystick" serves to identify areas of interest on the map. All of the input functions are linked to the digital computer through interface logic. Since the computer utilized in the embodiment illustrated has only a 1K memory for compactness, an auxiliary memory with associated control logic is connected thereto. Instructions for the computer comprise instructions for computing fallout cloud size, taking into account the initial conditions mentioned previously, dividing the cloud into multiple layers, computing the effects of meteorological conditions thereon, and accounting for many different particle sizes and settling rates whose radiative fallout contributions are summed into a dose. The dose constitutes output data for superposition over affected areas on the map. Dose levels are represented by various shades of gray in a variegated mosaic pattern projected by the CRT. An operator can manipulate the "joystick" so that dose rates and total dose at particular points of interest can be identified on the screen. The computer will automatically give a numerical total dose and dose rate reading at the points of interest identified by the operator.

The third image is projected from a circle generator which presents prompt effects, such as radiation, blast and thermal effects, in terms of circles of changeable diameter. The circle generator, for example, may be of the type described in the above referenced U.S. Pat. with the exception that in the presently described system, the generator is controlled by a programmable digital computer instead of the non-programmable analog computer used in the prior application.

Accordingly, the composite output display appearing on the screen includes a map with prompt effects and fallout displays superimposed thereon. The display on the screen changes as time dependent characteristics of the explosive become manifest in the equations solved by the digital computer, and as new data is entered into the system.

Referring now to the drawings, the inventive system is shown primarily in block diagram in FIG. 1 for purposes of simplicity, the individual components thereof being set forth thereinafter in such a manner as to generally describe an embodiment of the system utilized to produce the fallout patterns of FIGS. 2 and 3.

The system is controlled by a control panel **10** shown diagrammatically in FIG. 1 and in more detail in FIG. 4 which comprises the Map Display Input Panel **90**, the Prompt Effects Input Panel **91**, the Prompt Effects Readout Panel **92**, Fallout Input and Computer Controls Panel **93**, and the Fallout Readouts and Wind Data Panel **94**. The Map Display Screen **95** appears intermediate the Prompt Effects Readouts Panel **92** and the Fallout Readouts and Wind Data Panel **94**. Upon the Map Display Control Panel **90** are located the three positioning control levers or joysticks, one for the map (Map Position) **101**, one for the prompt effect circles (GZ — Circles) **102**, and one for an interrogator light or indicator of a point of interest (GZ — NR) **103** where GZ means ground zero and NR means numerical points; the radiation level selector in rads or kilorads **111**; map scale **112**, focus **114** and light intensity **113**; the display selector **115** for ground zero; Mode I, Mode II selector switch **120**, Multiweapons selector switch **121**, and Prompt/Fallout selector switch **122**. The Prompt Effects Input Panel **91** contains input controls for varying inputs relating to yield **105**, range **106**, H.O.B. (height of burst) **107**, and blast pressure **108**. Fallout system control switches include Start **104***a*, Halt **104***b*, and Resume **104***c*, and indicators Map Pwr **110***a*, Display/Hi volt **110***b*, and Computer Pwr **110***c* on the Fallout Input and Computer Controls Panel **93**. There are **20** independently selectable wind bands **119** with direction and speed data for each, each located at selectable altitudes **118** on the Fallout Readouts and Wind Data Panel **94**. A numerical readout **11**, in the actual embodiment, located on the Fallout Readout and Wind Data Panel **94** for ease of viewing, illustrates the time since initial blast for simulated 30 minute periods **117**, radiation in Rads/Hr **124**, Total Radiation **125**, and radiation level scale by showing various shades of gray **116**. The numerical readout **11** continues on the Prompt Effects Readout Panel **92** showing actual blast pressure **130**, an error indicator panel **131** which determines if an incorrect input was supplied by the operator, indication of type of weapon **132**, whether surface or air burst **133**, and thermal heat flux **134**. While the above description of the elements of the control panel **10** and numerical readout **11** has been rather extensive, it indicates the complexity of the inventive system and the type of information which can be fed thereinto or received therefrom, and the description is not intended to be inclusive, nor is it intended to limit the type of information which can be incorporated or provided by this novel system to that above described. A full and complete description is in U.S. Atomic Energy Commission technical report No. UCRL-50892, *Weapons Effect Display System* (*WEDS MOD II*), Volumes 1–6, Livermore, Calif. 94550, 1970–1971. The report is available from National Technical Information Service, U. S. Department of Commerce, 5285 Port Royal Road, Springfield, Va. 22151.

As shown in FIG. 1, the control panel **10** has four primary outputs to other portions of the system, these being indicated at **12, 13, 14** and **15**. Output **12** from control panel **10** is fed into a circle logic circuit **16** which is connected as indicated by lead **17** to a circle generator **18** which via a mirror **19** displays on a screen **20** as circles indicated at **21** the prompt effects indicated at **22**. The circle logic circuit is also connected to direct signals, indicated by lead **23**, to and receive signals, indicated by lead **24**, from a digital computer **25**. Control panel output **13** is directed to a control logic circuit **26** the output of which, indicated at **27** is fed to computer **25**. Control panel outputs **14** and **15** introduces input data to an interface logic circuit **28** for the calculation and display of two different patterns or modes indicated as Function A at **29** and Function B at **30**, each having outputs respectively indicated at **31** and **32** which are fed into the interface logic circuit **28**, and separately directed therefrom into computer **25** as indicated by leads **33** and **34**. The Function A mode compares the fallout prediction of an existing military pattern with the prediction pattern of the present system; while the Function B mode provides an accurate and more general display of the computer output. For example, the military prediction pattern described in Manual TM 3-210 (1962), "Fallout Prediction," Department of the Army, Washington, D.C., while the present prediction pattern has irregular contours as determined by wind, gravity, and the pertinent physical

characteristics of the detonations. FIG. 2, described in greater detail hereinafter, illustrates the Function A mode wherein a "Keyhole" fallout pattern results from the superimposition of the military prediction pattern on the prediction pattern of the present system. Note that while the military prediction pattern is a fixed regularly shaped pattern, the pattern illustrated by the present system is irregularly shaped to more accurately illustrate the characteristics of the detonation. FIG. 3 illustrates the Function B mode wherein a typical fallout pattern of the present system is shown at 9 hours after detonation, the circular patterns being a result of the geometry selected for the initial cloud configuration. The fallout patterns illustration in FIGS. 2 and 3 are projected on screen **20** via an output, indicated at **35** from computer **25** to a projection cathode ray tube (CRT) **36**, the fallout pattern, indicated at **37**, is projected from the CRT **36** via a mirror **38** to provide the fallout portion of an image **39** on screen **20.** A disk memory **40** is connected to receive from and feed to computer **25** information as indicated by leads **41** and **42.** Since the computer **25** utilized in the illustrated system has only a memory of, for example 1–4K, for compactness, the remote memory **40**, which for example is **10K**, enables the small computer **25** to operate the entire system. The numerical readout **11**, as described above, is connected to receive information from computer **25** as indicated by line **43.** A map-background projector **44** receives image-scale data, indicated at **45**, from computer **25**, the inputs therefor having been fed to computer **25** from control panel **10** via the control logic **26.** The thus selected map, background indicated at **46**, is projected from projector **44** via a mirror **47** to complete the image **39** on screen **20.** Thus, screen **20** simultaneously displays the map background **46**, the fallout pattern **37**, and the prompt effects **22**, thereby providing a unique image of a predicted nuclear detonation which image can be readily changed to illustrate the delayed effects of nuclear explosions with respect to a geographical area. If projection of the map background, fallout pattern and prompt effects can be made directly on screen **20**, the mirrors **19, 38** and **47** can be eliminated.

With the inventive system, as presently constructed, the fallout pattern can be followed for a simulated time period as long as **48** hours. An updated pattern is provided on the screen for each half hour period, and the real-time interval between consecutive patterns is adjustable from two seconds to tens of minutes. Alternatively, one can scan through a succession of patterns to reach the desired one. As the pattern develops, the operator can interrogate the system for more precise information. An interrogrator **48**, such as a blinking light, can be placed at any point of interest on the image **39** displayed on screen **20**, and an immediate readout of the dose rate and the total accumulated dose at that point can be obtained from the numerical readout **11.** The interrogator **48** can be moved to any point on screen **20** as indicated by the travel line **48'**.

FIG. 2 illustrates the military prediction pattern superimposed over the actual fallout pattern produced by the inventive system, this pattern being indicated at **49** on the screen **20** of FIG. **1.** As widely known, the military pattern is composed of two sections, Zones I and II with ground zero (GZ) located at the tip or point of Zone I; the pattern also being provided with three times reference lines indicated on FIG. **2** as 1 hr., 2 hr. and 3 hr. lines from ground zero. The Zones I and II are established such that a person located in Zone II will receive a dosage of less than 100 Rads in 6 hours while the dosage in Zone II is greater. Note that the actual fallout pattern as shown in FIG. 2 illustrates three different levels of radiation intensity within the frame of the military prediction pattern thereby providing a more accurate assessment of the dosage intensity of the fallout, the largest or heaviest being, of course, adjacent ground zero.

Input coefficients and variables in the illustrated system as pointed out above include height of burst, yield, decay coefficient, fission-to-fusion ratio, map scale, wind velocity and direction, activation products, etc. To simulate real conditions, wind velocity and direction can be changed while the problem is being run. Other inputs also can be varied. For example, the distribution of activity versus the size of the particles in the debris can be changed in order to experiment with the effect of soil characteristics. Alternatively, the operator need only turn a selector switch to call up any of seven preset activity-distribution curves stored in the memory (e.g., the Glasstone curve or those of Nevada Tuff, coral, etc.). Also, the fallout pattern projected on the screen has three levels of light intensity as illustrated in FIG. **3.** The radiation level associated with each intensity can be varied. In the early stages of fallout, levels such as 1,000, 3,000 and 10,000 rads may be appropriate; as decay proceeds, the levels can be lowered to, say 0.5, 1, and 3 rads.

Considering now in more detail the circle logic circuit **16** shown functionally in FIG. **1**, FIG. **5** illustrates the major components of the circle logic circuit comprising the input data interface **201** which transfers the data from the Prompt Effects Input Panel **91** switch positions, the Map Display Input Panel **90** switch position, and Read Only Memory (ROM) **96** via lines **12***a*, **12***b*, and **223** respectively. The Read Only Memory (ROM) **96** is the auxiliary memory linked to the digital computer **25.** Input data interface **201** in turn transfers the data on line **224** to the interface controller **202** where the data is decoded by conventional digital techniques into and out of the Digital Computer **25** via line **23.** Control signals emanating from the computer via line **24** to the interface controller **202** are shuttled to the output data interface **203** and from there to the Circle Generator **18** via line **17.** The decimal point encoders of the input data interface **201**, the binary coded decimal to decimal decoders of the output data interface **203**, and the register address selection circuits and address select timing logic of the interface controller **202** are all of the skill of the art design with conventional digital components — see for example, Vol. 4, Part 2 of the above referenced USAEC technical report No. UCRL–50892, in particular FIG. **17** on page 29 which is similar to FIG. **5** of this patent. The Prompt Effects Readout Panel **92** receives data from the output data interface **203** via line **228.** The Read Only Memory (ROM) **96** is a removable module containing logic circuitry that is hard wired to produce unspecified constants necessary for weapons or weapon types other than those described in Glasstone's *The Effect of Nuclear Weapons*, USAEC, Wash., D.C., 1962, Rev. Ed. 1964. The equations and constants from Glasstone are unclassified. The unspecified constants stored in the ROM will usually be classified but all will be protected as classified. The ROM is of conventional design and is

described in Vol. 3 of the referenced USAEC technical report No. UCRL–50892, particular reference being made to FIG. 4 on page 4 which is identical to FIG. 7 of this patent.

The control logic **26** shown functionally in FIG. **1** is more specifically named the Memory System Controller (fallout logic interface) and is considered in more detail in FIG. **6.** The Memory System Controller **26** synchronizes information transfers between the computer **25** and the disk memory **40,** the Fallout Readouts and Wind Data Panel **94**, the Fallout Input and Computer Controls Panel **93,** and the Prompt Effects Input Control Panel **91.** The Memory System Controller **26** also synchronizes the CRT **36** display to the disk memory **40** and transfers data from the disc memory **40** to the CRT **36** display via the CRT Display Controller **301.** The Memory System Controller **26** is logically partitioned into five functions: The interface controller **302,** the input data interface **303,** the output data interface **304,** the magnetic disc controller **305,** and the CRT display controller **301.** All data flowing between the digital computer **25** and the memory system controller **26** are routed through either the input data interface **303** or output data interface **304.** The input data interface **303** contains all the gates necessary to accept the data from the Prompt Effects Input Control Panel **91,** the Fallout Input and Computer Controls Panel **93.** The input data interface **303** is limited to transferring the data from the Fallout Readouts and Wind Data Panel **94** to the digital computer **25.** The output data interface **304** contains all the buffer registers necessary to drive the indicators on the fallout readouts and wind data panel **94,** and to load data onto the auxiliary and display sections of the disk memory **40.**

The operation of both data interfaces (**303** and **304**) is controlled by the interface controller **302.** Interface controller **302** decodes the control signals from the digital computer **25** and routes the data flow either from the selected data gates or to the selected data buffer registers in the data interfaces. The interface controller **302** also selects the wind group (from the fallout Readouts and Wind data panel **94**) to be sampled, selects the auxiliary memory field on the magnetic disc **40** onto or off which data are to be transferred, and selects the display field on the magnetic disc **40** to which data are to be transferred.

The magnetic disc controller **305** interfaces the magnetic disc unit **40** to the input data interface **303.** The magnetic disc controller **305** decodes data control words from the input data interface **303** and output data interface **304,** and times the data transfer between the interface controller **302** and the magnetic disc **40.** The magnetic disc controller **305** also decodes synchronizing signals from a timing track on the magnetic disc **40** for its own operation and to synchronize the CRT display controller **301.**

The CRT display controller **301** interfaces the Projection CRT **36** to the magnetic disc controller **301,** the disc memory **40,** and the Fallout Readouts and Wind Data Control Panel **94** (through the input data interface **303** and magnetic disc controller **305**). It routes the data to the CRT display from the magnetic disc's display field that is selected on the fallout readouts and wind data control panel. The data from the selected fields are mixed together in the CRT display controller **305.** The CRT display controller also controls flicker modulation on the data outputted from two of the display fields as well as the horizontal and vertical synchronizing signals from the magnetic disc controller **305.**

Detailed logic diagrams of the memory system controller (control logic) **26** major assemblies are contained in Vol. 4, Part 3 of the prior referenced USAEC technical report No. UCRL–50892 and show the skill in the art design utilizing conventional components, particular reference being made to FIG. E–1 on page 42 which is similar to FIG. **6** of this patent.

Function B shown diagrammatically in FIG. **1** is a function which computes the Army Fallout predicition model earlier referred to, i.e., that of a display consisting of lines and arcs roughly resembling a "keyhole" pattern. Function B, consisting of five program blocks and twelve subroutines, computes the keyhole's lengths, angles, lines, arcs, and other related information in display point coordinates in X and Y. The five program blocks and their specific functions are as follows:

FBA — Wind Vector Plot and Cloud Parameters. FBA determines if height of burst, yield, map scale, and effective wind speed are within the proper ranges for function B's operation and if not, will set an error alarm. In this block, function B begins to follow the step-by-step process by working with display points to construct the wind vector plot. Cloud parameters are reduced to display points as well. FBA's general role is to describe the wind vector plot for the next block.

FBB — Compute Angles Alpha and Beta. Alpha and beta refer to the angles made by the radial lines (on the X Y plot) of the predicted area. Also, FBB will allow for some unique wind situations that can change the "keyhole" to an expanded or a circular pattern.

FBC — Compute Adjustment Factors. FBC will compute the height of burst and fission-yield/total-yield adjustment factors as well as the Net Zones I and II (Zone I -- Immediate operational concern — radiation dose > 100 rad in 4 hr; Zone II — Moderate risk — radiation dose < 100 rad in 4 hr.) downwind distances. This is accomplished by equations which approximate the nomograms found in the earlier cited Army TM Manual TM–3–210, Change A. Should the height of burst adjustment factor be less than 1, or Zone I distance too small or large, an error alarm is set.

FBD — Compute Base Building Points. The blast pressure points are computed in this block. These points are the basic building points from which the final pattern will be constructed. A rough check is made on the minimum and maximum limits of the display and, if the limits are not met, an alarm is set.

FBE — Compute Final Fallout Pattern. Using the basic building points and indicators for the direction and type of fallout pattern, FBE computes the final fallout pattern to be presented on the display screen. A fine-grain check is made on the display and, if minimum and maximum requirements are not met, an error alarm is set.

The twelve subroutine's and details implementing the above five program blocks are contained in Vol. 5 of the above cited USAEC technical report No. UCRL–50892, particular reference being made to FIG. **4** on page 19, which is identical to FIG. **8** of this patent.

Function A shown diagrammatically in FIG. **1** is a function which computes the fallout time-variant intensity gradient display hereinbefore described. The large

particle immediate fallout wafers are placed on the function A display disc field, and then the other wafers are descended for the detonation — relative time entered at the Fallout Input and Computer Controls panel as TIME PERIOD (MODE I) or for a half-hour increment in detonation-relative time (MODE II) and these wafers in turn are placed on the display disc field. When this point is reached, sequence parameters cause control to be transferred to display gradient (FAC) discussed below, which monitors display control insertions. Five program blocks and five subroutines make up function A and the program blocks are as follows:

FAA — Calculate Immediate Fallout. FAA performs some calculations preliminary to the operation of the function as a whole, sets results into communication tables, and then computes two immediate fallout wafers. It leaves these in a cloud parameter table to be displayed by display gradient (FAC), which operates immediately after FAA. While descend wafers (FAB) and display gradient (FAC) may operate repeatedly for a single MODE II detonation, FAA operates only once in response to each START.

FAB — Descent Wafers. FAB calculates descent time for cloud wafers, sets indicators in a cloud parameters table that tell display gradient (FAC) which wafers should be displayed in a given cycle, and stores all wafer information necessary for displays. FAB does not handle immediate fallout wafers that are completely described by FAA. FAB is the program block in which repetitive operation begins in MODE II (and MODE I if RESUME is pressed). FAB exits to the fourth entrance of system control (CFA) unless a wafer radius is larger than (approximately) one-fourth of the display screen, when it returns to the second entrance to wait for START.

FAC — Display Gradient. FAC uses the cloud parameters table set up by FAA and FAB to calculate disc addresses for grid points covered by each descended wafer. It indicates rate and accumulated total absorbed activity, by grid point, on the function A data disc field so the gradient display need not be completely reconstructed at each MODE II increment. It records the change of this activity and places it on the function A display disc. FAC operates once following FAA and repeatedly, in MODE II, after FAB. It exits to the fourth entrance of system control (CFA).

FAD — Numerical Display. FAD operates automatically at HALT. Fad uses the cloud parameters table to calculate accumulated dose and dose rate and place them in display registers. It then monitors the display control sense lines for another request (caused by moving the joystick), for RESUME, for START, and for PROMPT/FALLOUT. When RESUME is pressed, FAD exits to the fourth entrance in system control (CFA). A sequence parameters table entry causes CFA to proceed as if it had detected RESUME. START causes FAD to exit to the third entrance to CFA, where processing of sequence parameters begins.

FAE — Wind Change. FAE simulates the descent of all wafers not yet on the ground to their new altitudes. Lateral displacement is computed and the new positions of the wafers are stored in the cloud parameters table. FAE operates only in response to the insertion of new winds at RESUME, the conditionality being established by sequence parameters and by the setting of indicators by read period and wind (CFC). It exits to the fourth entrance of system control (CFA).

The five subroutines and details implementing the above five program blocks are contained in Vol. 5 of the above cited USAEC technical report No. UCRL–50892, particular reference being made to Appendix E on page 141 which is incorporated into this patent as Appendix E.

The digital computer **25** shown diagrammatically in FIG. **1** is the heart of the subject Graphics Display System. It receives inputs from the control panel switches including the wind data switches and the prompt effects switches; it performs all calculations; it then outputs numerical readouts to the output indicators and generates fallout patterns on the CRT display. All communication between the computer and its peripheral equipment is routed through the memory system controller **26** (FIG. **6**); however, the computer, at all times, retains complete control of all data transfers and processing.

The operation of the digital computer is divided into two basic groups, i.e., the fallout computer program and the prompt effects computer program. During the fallout program operation, most of the fallout program resides on the magnetic disc. Core memory (of the computer) is occupied, while fallout is in operation, by a table of constants, tables of input values, a program that reads prompt effects from disc, and a control program that reads program blocks from disc to core and transfers control to them. When each program block has finished operating, it returns control to the control program, and the next program block is read in and operated. The sequence of operations is determined by a sequence parameters table, from which the control program obtains core and disc addresses that enable it to read blocks into core.

The fallout program system may be thought of as comprising four functions:

1. A load function that places the program system on disc, places portions of it in core memory, constructs the sequence parameters table, and transfers control to the control function.

2. A control function that comprises the control program and the program blocks that read inputs and converts them to the formats required by function A and function B. The control program uses the sequence parameters table to determine the order in which program blocks are to be read into core, tests the input lines (START, RESUME, PROMPT/FALLOUT) that control the presentation of function A displays and transfers to prompt effects.

3. A function A that calculates output information for the gradient display and the three numerical displays and outputs it.

4. A function B that calculates output information for the keyhole display and outputs it.

The Load Function, (1) above, comprises three program blocks and three subroutines. The program blocks are described below:

LPA — Load From Tape. LPA reads the load control table from the tape that it finds in the tape reader and places it, along with LPB, LPC, and subroutine LB on disc. It then reads in the rest of the system, placing the permanent core program blocks on disc as well as in core, and exits to construct sequence parameters (LPC).

LPB — Load From Disc. LPB is read from disc into core, together with the load control table, LPC, and subroutine LP, by the use of the disc-to-core bootstrap

(see FIG. 3, page 18, and Appendix D, Vol. 5, USAEC technical report No. UCRL–50892 FIG. 3 being identical to FIG. 9 of this patent and Appendix D being incorporated into this patent as Appendix D). Its function is to restore the system to operation when a computer malfunction has damaged the program in core but left the disc intact. It uses the load control table to read those program locks from disc to core which occupy permanent places in core during system operation. It exits to construct sequence parameters (LPC).

LPC — Construct Sequence Parameters. LPC derives the sequence parameters table from the load control table, placing it in a temporary location in core, and exits to the control function (CFA).

The Control Function, (2) above, comprises five program blocks and eight subroutines. The program blocks are described below:

CFA — System Control. In general, processing the sequence parameters table consists of obtaining from it a disc address, a core address, and the number of words to be transferred; reading a program block from disc to core; and transferring control to an address given in the sequence parameters table. CFA has four entrances. The entrance used by load function places the reconstructed load control table into sequence parameters, tests the prompt/fallout switch, waits until START is pressed, and then commences to operate the system from the first entry in the sequence parameters table. The second entrance is used at the end of a detonation or when a function A error occurs. It sets error lights, tests the prompt/fallout switch, and awaits START. The third entrance is the same as the first, except that the START light is not sensed. This is used when START has been sensed in another program block. The fourth entrance resumes processing the sequence parameters table from the point at which it was interrupted by transfer of control to another program block. This entrance is used by all program blocks that reside on disc. It is also used when an error in function B occurs.

CFB — Clear and Read Inputs. CFB clears all displays and flip-flops and reads all inputs except TIME PERIOD, RAD LEVEL SELECTOR, and wind data. Inputs are legality — checked and converted from BCD to binary working values. CFB exits to the fourth entrance of system control (CFA) unless an input error is found, in which case it exits to the second entrance to wait for START.

CFC — Read Period and Wind. CFC reads TIME PERIOD, RAD LEVEL SELECTOR, and wind data, legality-checks them, and determines if new wind data have been inserted by comparing them with last inserted data; in such instances as HALT has been depressed, wind data changed, and RESUME depressed. CFC operates twice in the system sequence: once just after START and once as a part of the function A display cycle. CFC exits to the fourth entrance of system control (CFA) unless START has been sensed, in which case it exits to the third entrance — or unless an input error is found, in which case it returns to the second entrance to wait for START. It also tests the PROMPT/ FALLOUT swtich and jumps to PFDL if on PROMPT.

CFD — Cartesion Wind Vectors. CFD computes $\dot{x}_w$ and $\dot{y}_w$ from inputs ρ_w, θ_w. It operates twice in the system sequence, following the read period and wind (CFC): once after START and once as a part of the function A display cycle, conditioned upon the insertion of new wind data. Conditionality is co-determined by the position of the CFC entry in the sequence parameters table and by an indicator set by CFC. It exits to the fourth entrance of system control (CFA).

PFDL — Prompt/Fallout Disc Load. It loads the prompt effects program from disc to core when the PROMPT/FALLOUT switch is set to PROMPT.

The subroutine's and details implementing the load function and control function program blocks are contained in Vol. 5 of the above cited USAEC technical report No. UCRL–50892. Function A and Function B have previously been discussed.

Sections of particular interest in Vol. 5 are entitled "Fallout Load Function Tape" and "Operational System Tape" on pages 14 and 15 and which are incorporated in this patent as follows:

Fallout Load Function Tape

This tape is read into core in its entirety by a bootstrap loader program (see Appendix C) inserted by the switches on the computer console. Its order on the tape determines the order in which it will appear in core. Because LPB, LPC, and subroutines LA, LB, and LE are read in together when the system is reloaded from disc, they are contiguous in core and on tape. Table 1 illustrates the tape format. No attempt has been made to represent the relative lengths of the program blocks.

LBA	LPB	LPC	LB	LPB (cont.)	LPA (cont.)	LA	LE
Load point							

Table 1 Load function binary tape

OPERATIONAL SYSTEM TAPE

Two constraints on tape format exist: the load control table must be at tape load point and be the first entry read by the load function, and the order of blocks in the load control table must be the order of blocks on the tape. Table 2 illustrates this. Because the load control table is generally in the order of program block operation, that order is observed in constructing the binary tape.

Program blocks that reside permanently in core during a fallout operation may be placed anywhere on the tape, as long as they occupy the same position in the load control table. Program blocks CON, CFA, and CC must always be on tape and their entries included in the load control table. Other program blocks may be omitted if desired. This allows changing or loading a program block without making or loading a new system tape.

LOAD CONTROL TABLE				PROGRAM BLOCKS			
	Entries for						
CFB	CFC	CFD	FBA				
	Etc.			CFB	CFC	CFD	FBA
					Etc.		
Load point							

Table 2. Operational system binary tape.

The prompt effects computer program resides primarily on the disc. While prompt effects is in operation, the core memory is occupied by a program that reads the fallout program and a program which reads program blocks from disc to core and transfers control to them. When each program block has finished operating, it returns control to the read-program-blocks pro-

gram, and the next program block is read in and operated. The sequence of operations is determined by a sequence parameters table from which the read-disc program obtains core and disc addresses (which enable it to read blocks into core) and the operating sequence of program blocks. The sequence parameters table is constructed by the program that loads the system into the computer. Its content is determined by the load control table. The actual data in the prompt effects load control table is contained in Appendix A of Vol. 5, USAEC technical report No. UCRL-50892, Appendix A being incorporated into this patent as Appendix A.

The prompt effects program may be thought of as comprising five functions:

1. A load function that places the program system on disc, places portions of it in to core memory, constructs the sequence parameters table from the load control table, and transfers control to the read-disc program block;

2. A control function that comprises the read-program-blocks program mentioned above: The program blocks that read and convert input, convert and out output, and control the mode and multiweapon sequencing and storage [the read-disc program uses the sequence parameters table to determine the order in which program blocks are to be read into core and tests the input lines (START, PROMPT/FALLOUT) that control the execution of prompt effects or transfers to fallout];

3. A Mode I function that calculates information for MODE I;

4. A Mode II function that calculates information for MODE II;

5. A probability function that calculates probability of damage for Mode I or II.

The Load Function, (1) above, for prompt effects comprises three program blocks briefly described below:

LPA — Load From Tape. Same as in the fallout effects system program except that the prompt effects system data is read in.

LPB — Load from Disc. Same as in the fallout effects system program except that the disc-to-core bootstrap procedure for prompt effects is contained in Appendix B of Vol. 2, USAEC technical report No. UCRL-50892, Appendix B being incorporated into this patent as Appendix B.

LPC — Construct Sequence Parameters. Same as in fallout effects system program.

The programming sequence is illustrated by flowcharts found in FIGS. 10 and 11 which are identical to the flowcharts on pages 21 and 22 of Vol. 6, USAEC technical report No. UCRL-50892.

The Control Function, (2) above, for prompt effects, comprises five program blocks described briefly below:

CFA — Read Program Blocks. In general, processing the sequence parameters table consists of obtaining from it a disc address, a core address, and the number of words to be transferred; reading a program block from disc to core; and transferring control to an address given in the sequence parameters table. CFA has four entrances. One places the reconstructed load control table at the address given in CFA, tests the prompt fallout switch, proceeds to wait until START is pressed, and then commences to operate prompt effects from the first entry in the sequence parameters table, unless fallout is called for. This is the entrance used by the load function. The second entrance is used after a dead strat; the disc is warmed up for 5 sec., and then the program continues as in the next entrance. The third entrance is used when a fatal error occurs (such as disc error); it sets error lights, tests PROMPT/FALLOUT, and awaits START. The fourth entrance resumes processing the sequence parameters table from the point at which it was interrupted by transfer to control to another program block. This entrance is used by all program blocks.

CFB — Clear and Read Inputs. CFB clears the error words and reads all inputs from the front control panel and the ROM (if inserted). It will convert the BCD data to floating point and check the data for illegal entries. If illegal entries are found, it will set the input error and start lights and wait for START Or PROMPT/FALLOUT to be pushed. If all input is acceptable, it will enter the data in the proper core locations and exit to CFA to read the next program block. The programming sequence is illustrated by flowcharts found in FIGS. 12, 13 and 14, which are identical to the flowcharts on pages 24, 25 and 26, of Vol. 6, USAEC technical report No. UCRL-50892.

CFC — Mode and Multiweapon Control. CFC has two entrances. The first entrance is entered after the input routine. It will test for mode, and single or multiweapon. If single-weapon or multiweapon compute is set, it will exit to CFA to read and execute the Mode I or II functions and the probability function. If multiweapon store or recall is set, it will perform the store or recall and exit to CFA to read the output program block. The second entrance to CFC is from a single-weapon or multiweapon compute after the calculations have been done. CFC will fill the proper output buffers and exit to CFA to read the output program block. The programming sequence is illustrated by flowchart found in FIG. 15, which is identical to the flowchart on page 30 of Vol. 6, USAEC technical report No. UCRL-50892.

CFD — Output. CFD will convert and display the data in the output buffer OB, including circle generator ranges and colors. CFD will also set the error lights if they are indicated in the error word. CFD will exit to CFA to restart the prompt effects cycle. The programming sequence is illustrated by flowcharts found in FIGS. 16 and 17, which are identical to the flowcharts on pages 35 and 36 of Vol. 6, USAEC technical report No. UCRL-50892.

CFE — Prompt/Fallout Disc Load. CFE loads the fallout-program disc-load program block from disc to core and transfers control to it when the PROMPT-/FALLOUT switch is set to FALLOUT. The programming sequence is illustrated by the flowchart found in FIG. 12 which is identical to the flowchart on page 24 of Vol. 6, USAEC technical report No. UCRL-50892.

The Mode I Function, (3) above, for prompt effects, comprises four program blocks which are executed whenever a Mode I calculation is called for in single-weapon or multiweapon compute. They are briefly described below:

M1A — Mode I Radiation and Thermal. M1A will compute the slant range and call the routine to compute the attenuation factor. It then computes the gamma, neutron, or total radiation and thermal flux for the input range. If any computed values are out of the specified range, error indicators will be set. M1A then

exits to CFA to read in M1B The programming sequence is illustrated by flowcharts found in FIGS. **18**, **19** and **20** which are identical to the flowcharts on pages 43, 44 and 45 of Vol. 6, USAEC technical report No. UCRL–50892.

MIB — Mode I Blast. M1B will compute the peak static over-pressure, and dynamic pressure. M1B then determines which pressure is to be displayed and checks for computed values out of range, setting error indicators if necessary. M1B exits to CFA to read the probability function, PRB. The programming sequence is illustrated by flowcharts found in FIGS. **21** and **22** which are identical to the flowcharts on pages 49 and 50 of Vol. 6, USAEC technical report No. UCRL–50892.

MDC — Mode I and II Blast Data. This program block does no computations. It contains the data for the model that calculates the peak static overpressure or pressure range (depending on mode).

MDD — Mode I and II Subroutines. This program block contains various subroutines used in M1A and M2A radiation and thermal calculations. These routines are called directly from the program blocks needing them, and control is returned to the calling program.

The Mode II Function, (4) above, for prompt effects, comprises four program blocks which are executed wherever a Mode II calculation is called for in single-weapon or multiweapon compute. They are briefly described below:

M2A — Mode II Radiation and Thermal. M2A first computes the attenuation factor. Then the radiation range for the given radiation is computed, followed by the thermal range for the input thermal flux. M2A checks for computed values out of range, sets any necessary error indicators, and then exits to CFA to read in M2B. The programming sequence is illustrated by flowcharts found in FIGS. **23** and **24** which are identical to the flowcharts on pages 67 and 70 of Vol. 6, USAEC technical report No. UCRL–50892.

M2B — Mode II Blast. M2B will determine which pressure has been input (dynamic or static) and compute the other. The blast range is then computed from the static pressure. M2B checks for computed values out of range, sets any necessary error indicators, and then exits to CFA to read the probability function PRB. The programming sequence is illustrated by flowcharts found in FIGS. **25**, **26** and **27** which are identical to the flowcharts on pages 75, 76 and 77 of Vol. 6, USAEC technical report No. UCRL–50892.

MDC — Mode I and II Blast Data. Same as in Mode I Function.

MDD — Mode I and II Subroutine. Same as in Mode I Function.

The probability Function, (5) above, for prompt effects, comprises one program block briefly described below:

PRB — Probability of Damage. PRB will first determine if a probability of damage P_K calculation should be made. If not, P_K is set to **0**, and PRB exits to CFA to read CFC. If so, then the vulnerability is computed by using the input vulnerability number and a correction factor computed in PRB. Then P_K is computed, and PRB exits to CFA to read in CFC. The programming sequence is illustrated by flowcharts found in FIGS. **28** and **29** which are identical to the flowcharts on pages 82 and 83 of Vol. 6, USAEC technical report No. UCRL–50892. Other sections of particular interest in Vol. 6 are entitled "Prompt Effects Load Function Tape" and "Operational System Tape" on pages 13 and 14 and which are incorporated in this patent as follows:

Prompt Effects Load Function Tape

The prompt effects load function tape is read into core in its entirety by a bootstrap loader program (see Appendix C) inserted by the switches on the computer console. Its order on the tape determines the order in which it will appear in core. Because LPB, LPC, and subroutines LA, LB, and LE are read in together when the system is reloaded from disc, they are contiguous in core and on tape. Table **1** illustrates the tape format. (No attempt has been made to represent the relative lengths of the program blocks.)

LBA	LPB	LPC	'LB	LPB (cont.)	LPA (cont.)	LA	LE
Load point							

Table 1 Load Function Binary Tape

Operational System Tape

There are two constraints on tape format: the load control table must be at the tape load point and be the first entry read by the load function, and the order of blocks in the load control table must be the order of blocks on the tape. Table **3** illustrates this. Because the load control table is generally in the order of program block operation, that order is observed in constructing the binary tape, when possible.

Program blocks that reside permanently in core during prompt effects operation may be placed anywhere on the tape, as long as they occupy the same position in the load control table. Program blocks CFA and CFE must always be on tape and their entries included in the load control table. Other program blocks may be omitted if desired. This allows changing or loading a program block without making or loading a new system tape. If a block is omitted on tape, the load indicator for that block must be set to **0** in the load control

LOAD CONTROL TABLE				PROGRAM BLOCKS		
Entries for						
PCON	SBR1	SBR2	MDD			
Etc.				PCON	SBR1	SBR2
				18MDD		
Load point						

Table 3 Operation system binary tape

Details implementing the prompt effects computer program blocks are contained in Vol. 6, USAEC technical report No. UCRL–50892 hereinbefore referenced as particularly pointed in the foregoing paragraphs.

The interface logic **28** shown diagrammatically in FIG. **1** is the generic representation of the input data interface **303**, the interface controller **302**, and the output data interface **304** of the memory system controller **26** for the fallout logic interface shown in FIG. **6**; and the input data interface **201**, the interface controller **202**, and the output data interface **203** of the memory system controller **16** for the prompt effects logic interface shown in FIG. **5**.

The digital computer **25** may, for example, be a Varian Data Machine 6201, the disc memory **40** may be a Data Development Corp. unit, and other compo-

nents of the system are conventional off-the-shelf units particularly adapted for this system.

It is thus seen that the present invention provides as composite output display appearing on the screen which includes a map with prompt effects and a fallout pattern superimposed thereon, the display changing as time dependent characteristics of the explosive become manifest in the equations solved by the computer, and as new input data is entered.

Appendix A

Tables of Constants

Table A0. Radiation levels for function A display.

Index	Radiation levels Low	Medium	High
1	0.3	1.0	3.0
2	0.1	3.0	10.0
3	3	10.0	30
4	10	30	100
5	30	100	300
6	100	300	1 K
7	300	1 K	3 K
8	1 K	3 K	10 K
9	10	300	3 K

Table A1. Map scale in NM, Q_q.

q	Q (NM)
0	0.217
1	0.478
2	0.869
3	1.912
4	3.580
5	7.875
6	0.043
7	0.094

Table A2. Decay exponent, N_n (function A only).,

n	N
0	-1.1
1	-1.2
2	-1.3

Table A3. Coefficient of activity, C_c (function A only).

c	C
0	0.85
1	1.27
2	1.69
3	2.11
4	2.54
5	2.98
6	3.38
7	3.90

Table A4. Wind band depth, A_a

a	A
0	2.00
1	4.00
2	5.00
3	6.562 (2000 meters)

Table A5. Particle parameters (function A).[a]

j - F(W,Z_b)	i = particle size index	r = particle size, microns	p = portion of total fallout
Glasstone	0	500 (r_{max})	0.001
	.	362	0.002
	.	262	0.008
0	.	190	0.023
	.	138	0.054
	.	100	0.102
	.	72	0.155
	.	53	0.194
	.	38	0.195
	.	27	0.160
	10	20 (r_{min})	0.106
Knox	0	500	0.002
	.	362	0.007
1	.	262	0.020
	.	190	0.048
	.	130	0.092
	.	100	0.142
	.	72	0.183
	.	53	0.187
	.	38	0.156
	.	27	0.105
	10	20	0.058
Coral	0	500	0.024
2	.	362	0.043
	.	262	0.068
	.	190	0.096
	.	130	0.122
	.	100	0.139
	.	73	0.142
	.	53	0.130
	.	38	0.106
	.	27	0.078
	10	20	0.052
Tuff	0	500	0.048
	.	362	0.061
3	.	262	0.074
	.	190	0.086
	.	130	0.097
	.	100	0.106
	.	73	0.111
	.	53	0.112
	.	38	0.109
	.	27	0.103
	10	20	0.093
4	0		
	.	Spare	
	10		
5	0		
	.		
	.	Spare	
	10		

[a]See UCRL-50802, Vol. 2.

Table A6. Cloud parameters (function B)

Yield	Cloud top height (feet)	Cloud bottom height (feet)	Cloud radius (miles)
100 MT	120,000	63,000	63.75
95	120,000	63,000	63.75
90	119,000	63,000	63.75
85	119,000	63,000	62.00
80	118,000	63,000	60.00
75	117,000	62,750	58.00
70	117,000	62,750	57.00
65	116,000	62,750	55.00
60	115,500	62,750	53.00
55	115,000	62,750	52.00
50	114,000	62,500	50.00
45	113,000	62,500	47.00
40	112,000	62,500	45.00
35	111,000	62,250	43.00
30	109,000	62 250	40.00
25	107,000	62,250	37.00
20	105,000	62,000	34.00
15	102,000	61,500	30.00
10	98,000	61,000	25.00
9.5	98,000	61,000	25.00
9.0	97,000	61,000	24.00
8.5	97,000	60,750	24.00
8.0	96,000	60,750	23.00
7.5	95,000	60,500	22.00
7.0	94,000	60,500	22.00
6.5	94,000	60,500	21.00
6.0	93,000	60,250	20.00
5.5	92,000	60,000	20.00
5.0	91,000	60,000	19.00
4.5	90,000	59,750	18.50
4.0	89,000	59,500	17.50
3.5	88,000	59,000	17.00
3.0	86,000	58,500	15.00
2.5	84,500	58,250	14.50
2.0	82,500	56,500	13.00
1.5	79,500	56,250	11.50
1.0	76,000	55,000	9.75
950 KT	75,500	54,500	9.50
900	75,000	54,250	9.25
850	74,000	54,000	9.00
800	73,500	53,500	8.75
750	73,000	53,250	8.50
700	72,250	53,000	8.25
650	72,000	52,500	8.00
600	71,000	52,000	7.75
550	70,000	51,500	7.50
500	69,000	51,000	7.25
450	68,000	50,250	7.00
400	67,000	49,500	6.50
350	66,000	48,500	6.25
300	64,250	47,500	5.75
250	62,500	46,000	5.50

Table A6 (Continued).

Yield	Cloud top height (feet)	Cloud bottom height (feet)	Cloud radius (miles)
200 KT	60,500	44,000	5.00
150	58,000	42,000	4.50
100	54,000	39,000	3.75
95	53,000	38,500	3.50
90	53,750	38,000	3.50
85	52,000	37,500	3.50
80	51,500	37,500	3.50
75	51,000	37,000	3.25
70	50,000	36,250	3.25
65	49,000	35,500	3.00
60	48,500	35,000	3.00
55	47,500	34,500	3.00
50	47,000	34,000	2.75
45	45,750	33,000	2.75
40	44,500	31,750	2.50
35	43,000	31,000	2.50
30	41,000	29,500	2.25
25	40,000	28,000	2.00
20	38,000	26,000	2.00
15	35,000	24,000	1.75
10	31,000	21,000	1.50
9.5	30,000	20,500	1.50
9.0	29,500	20,000	1.50
8.5	29,000	19,500	1.25
8.0	28,000	19,000	1.25
7.5	27,500	18,500	1.25
7.0	27,000	18,000	1.25
6.5	26,000	17,500	1.25
6.0	25,500	17,000	1.25
5.5	24,000	16,000	1.00
5.0	23,500	15,500	1.00
4.5	22,500	14,500	1.00
4.0	21,000	13,500	1.00
3.5	20,000	12,500	1.00
3.0	18,500	11,500	1.00
2.5	17,000	10,250	0.75
2.0	15,000	8,500	0.75
1.5	11,500	6,750	0.75
1.0	9,000	4,750	0.50
0.95	9,000	4,750	0.50
0.90	8,750	4,750	0.50
0.85	8,500	4,500	0.50
0.80	8,500	4,500	0.50
0.75	8,250	4,250	0.50
0.70	8,000	4,000	0.50
0.65	8,000	4,000	0.50
0.60	8,000	4,000	0.50
0.55	7,750	3,750	0.50
0.50	7,750	3,750	0.50
0.45	7,500	3,500	0.50

Table A6 (Continued).

Yield	Cloud top height (feet)	Cloud bottom height (feet)	Cloud radius (miles)
0.40 KT	7,500	3,500	0.25
0.35	7,500	3,500	0.25
0.30	7,500	3,500	0.25
0.25	7,250	3,250	0.25
0.20	7,250	3,250	0.25
0.15	7,250	3,250	0.25
0.10	7,000	3,000	0.25

Table A7. Miscellaneous (function A only).[a]

Symbol	Calculation	Present value	Units
	Exponents		
E1	Cloud heights	0.25	
E2	Cloud heights	0.50	
E3	Cloud heights	5.00	
E4	Cloud radius	0.40	
E5	Descent rate	1.50	
E6	Diffused cloud radius	2.00	
E7	Diffused cloud radius	1.33	
E8	Diffused cloud radius	0.50	
	Other		
K1	Cloud heights	2.53	–
K2	Cloud heights	1.15	–
K3	Cloud heights	1.02	–
K4	Cloud heights	0.47	–
K5	Cloud heights	0.55	–
K6	Cloud heights	12.35	minutes
K7	Cloud radius	0.026	–
K8	Proportion of available radioactivity in immediate fallout	0.10	–
K9	Proportion of available radioactivity in upper one-third of mushroom stem	0.10	–
K10	Proportion of available radioactivity in nuclear cloud	0.50	–
K11	All activities	0.75	–
K12	All activities	1.00	–
K13	Immediate fallout wafer radius	1.00	–
K14	Immediate fallout wafer radius	0.17	–
K15	Time of fall	0.18	hours
K16	Time of fall	43.00	hours

Table A7 (Continued).

Symbol	Calculation	Present value	Units
	Other		
K17	Diffused cloud radius	0.40	–
K18	Immediate fallout decay	0.18	hours
K19	Proportion of immediate fallout in large immediate wafer	0.85	–
K20	Proportion of immediate fallout in small immediate wafer	0.15	–

[a]The following literal constants may be changed through use of switches on the computer console.

Table A8. Miscellaneous literature program constants (function B only).

Symbol	Calculation	Present value	Units
K30	Minimum yield boundary value	100	tons
K31	Time of fall	12	KFT
K32	Time of fall	34	KFT
K33	Time of fall	63	KFT
K34	Time of fall	10	KFT/hr
K35	Time of fall	8	–
K36	Time of fall	36	KFT
K37	Time of fall	110	KFT/hr
K38	Time of fall	18	–
K39	Time of fall	210	KFT
K40	Time of fall	290	KFT/hr
K41	Time of fall	25	KFT
K42	Time of fall	19	KFT/hr
K43	Zone I distance	50.370026	–
K44	Zone I distance	58.140015	–
K45	Zone I distance	7.230011	–
K46	Zone I distance	95.360016	–
K47	Height of burst adjustment factor	6.00	–
K48	Height of burst adjustment factor	2.700012	–
K49	Height of burst adjustment factor	0.930023	–
K50	Height of burst adjustment factor	17.960022	–
K51	Height of burst adjustment factor	0.00004	–
K52	Height of burst adjustment factor	0.0000032	–
K53	Height of burst adjustment factor	0.00000098	–
K54	Fission yield/total yield adjustment factor	7.680023	–
K55	Fission yield/total yield adjustment factor	2.360016	–
K56	Maximum height of burst boundary value	8500	feet

Table A 9 Display dot speed.

Fast	20 sec/128 grid pts
Slow	· 8 sec/128 grid pts

Table A10. Interpolation table for height of burst adjustment factor.

E_H	A_H
1.000	0.0
0.980	0.10
0.957	0.20
0.932	0.30
0.893	0.40
0.853	0.50
0.798	0.60
0.722	0.70
0.615	0.80
0.438	0.90
0.309	0.95
0	1.00

Table A11. Interpolation table for base factor (G)

E_H	G
1.200	0
1.150	0.20
1.100	0.30
1.050	0.48
1.000	0.53
0.980	0.59
0.957	0.62
0.932	0.65
0.893	0.69
0.853	0.73
0.798	0.77
0.722	0.82
0.615	0.88
0.438	0.94
0.309	0.97
0	1.00

Table A12. Interpolation table for fission yield/total yield adjustment factor (A_F).

E_F	A_F
0.000	0.10
0.242	0.20
0.402	0.30
0.516	0.40
0.626	0.50
0.718	0.60
0.790	0.70
0.863	0.80
0.933	0.90
1.000	1.00

Appendix B

BOOTSTRAP PROGRAMS

Entering a Bootstrap Program

On the computer front panel (Fig. 2), perform the following steps:

1. Press SYSTEM RESET.
2. Raise REPEAT.
3. Raise U (all other register switches—X, B, A, P—must be down); press RESET.
4. Set BIT SWITCHES: 0 101 100 000 000 000.
5. Depress U; raise P; press RESET.
6. Set BIT SWITCHES: 0 000 111 111 011 101.
7. Depress P; raise A.
8. Depress RESET.
9. Set bit switches to a program word from the listing of the appropriate Bootstrap Loader: Tape-to-Core Bootstrap Loader for Fallout or Prompt Effects (Table B-1), Disc-to-Core Bootstrap Loader for Fallout (Table B-2), or Disc-to-Core Bootstrap Loader for Prompt Effects (Table B-3).
10. Press STEP.
11. Repeat 8, 9, and 10 until all words of the Bootstrap Loader have been entered, then continue.
12. Depress A, raise U, press RESET.
13. Set BIT SWITCHES: 0 001 100 000 000 000.
14. Depress U, raise P, press RESET.
15. Set BIT SWITCHES: 0 000 111 111 011 101.
16. Depress P, raise A.
17. Press STEP. Compare the word that appears in the register lights with the first (then second, third, etc.) word of the Bootstrap Loader just entered. Repeat step 17 until all words have been verified. If a word is in error, repeat steps 3 through 10 for only the word and its address. Continue with 18 when all words have been verified to be correct.
18. Depress A, raise U, press RESET.
19. Depress U, raise X, press RESET.
20. Depress X, raise P, press RESET.
21. Set BIT SWITCHES: 0 000 111 111 101 000.
22. Depress P, depress REPEAT.
23. Press SYSTEM RESET, press RUN. The STEP light will go off, and the RUN light will come on and remain on. If this does not occur, return to step 12.

Table B 1. Tape-to-core bootstrap loader for fallout or prompt effects.

Address						Program word					
0	000	111	111	011	101	1	000	010	101	000	001
0	000	111	111	011	110	0	000	100	010	101	000
0	000	111	111	011	111	0	000	001	000	000	100
0	000	111	111	100	000	0	000	000	000	000	000
0	000	111	111	100	001	0	000	100	010	000	001
0	000	111	111	100	010	0	000	100	010	100	001
0	000	111	111	100	011	0	000	100	100	100	110
0	000	111	111	100	100	0	000	001	000	001	000
0	000	111	111	100	101	0	000	111	111	101	001
0	000	111	111	100	110	0	110	101	000	000	000
0	000	111	111	100	111	0	000	101	001	100	100
0	000	111	111	101	000	0	000	101	001	000	010
0	000	111	111	101	001	1	000	001	010	000	001
0	000	111	111	101	010	0	000	111	111	011	101
0	000	111	111	101	011	0	000	001	000	000	000
0	000	111	111	101	100	0	000	111	111	101	001

Table B-2. Disc to-core bootstrap loader for fallout.

Address						Program word					
0	000	111	111	011	101	1	000	011	001	100	010
0	000	111	111	011	110	0	000	110	001	100	000
0	000	111	111	011	111	0	011	111	111	000	000
0	000	111	111	100	000	0	000	001	000	001	000
0	000	111	111	100	001	0	000	000	000	111	101
0	000	111	111	100	010	0	000	110	001	010	000
0	000	111	111	100	011	0	100	000	000	000	000
0	000	111	111	100	100	1	000	001	001	000	010
0	000	111	111	100	101	0	000	111	111	111	011
0	000	111	111	100	110	0	000	001	000	000	000
0	000	111	111	100	111	0	000	111	111	100	100
0	000	111	111	101	000	1	000	001	100	000	010
0	000	111	111	101	001	0	000	111	111	101	100
0	000	111	111	101	010	0	000	001	000	000	000
0	000	111	111	101	011	0	000	111	111	101	000
0	000	111	111	101	100	0	000	110	000	001	000
0	000	111	111	101	101	1	111	111	111	001	001
0	000	111	111	101	110	0	000	110	000	010	000
0	000	111	111	101	111	0	010	011	101	110	101
0	000	111	111	110	000	0	000	101	011	010	010
0	000	111	111	110	001	0	000	001	000	010	000
0	000	111	111	110	010	0	000	111	111	110	101
0	000	111	111	110	011	0	000	001	000	000	000
0	000	111	111	110	100	0	000	111	111	110	000
0	000	111	111	110	101	0	000	101	001	001	001
0	000	111	111	110	110	0	000	001	000	000	100
0	000	111	111	110	111	0	000	111	111	101	110
0	000	111	111	111	000	1	000	000	001	000	010
0	000	111	111	111	001	0	000	110	000	011	000
0	000	111	111	111	010	0	000	000	000	111	100
0	000	111	111	111	011	1	000	010	110	010	010
0	000	111	111	111	100	0	110	101	000	000	000
0	000	111	111	111	101	0	000	101	001	100	100
0	000	111	111	111	110	0	000	001	000	000	000
0	000	111	111	111	111	0	000	111	111	011	101

Table B-3. Disc-to-core bootstrap loader for prompt effects.

Address						Program word					
0	000	111	111	011	101	1	000	011	001	100	010
0	000	111	111	011	110	0	000	110	001	100	000
0	000	111	111	011	111	0	011	111	111	000	000
0	000	111	111	100	000	0	000	001	000	001	000
0	000	111	111	100	001	0	000	000	000	111	101
0	000	111	111	100	010	0	000	110	001	010	000
0	000	111	111	100	011	0	100	000	000	000	000
0	000	111	111	100	100	1	000	001	001	000	010
0	000	111	111	100	101	0	000	111	111	111	011
0	000	111	111	100	110	0	000	001	000	000	000
0	000	111	111	100	111	0	000	111	111	100	100
0	000	111	111	101	000	1	000	001	100	000	010
0	000	111	111	101	001	0	000	111	111	101	100
0	000	111	111	101	010	0	000	001	000	000	000
0	000	111	111	101	011	0	000	111	111	101	000
0	000	111	111	101	100	0	000	110	000	001	000
0	000	111	111	101	101	1	111	111	111	001	001
0	000	111	111	101	110	0	000	110	000	010	000
0	000	111	111	101	111	0	010	011	101	110	101
0	000	111	111	110	000	0	000	101	011	010	010
0	000	111	111	110	001	0	000	001	000	010	000
0	000	111	111	110	010	0	000	111	111	110	101
0	000	111	111	110	011	0	000	001	000	000	000
0	000	111	111	110	100	0	000	111	111	110	000
0	000	111	111	110	101	0	000	101	001	001	001
0	000	111	111	110	110	0	000	001	000	000	100
0	000	111	111	110	111	0	000	111	111	101	110
0	000	111	111	111	000	1	000	000	010	000	010
0	000	111	111	111	001	0	000	110	000	011	000
0	000	111	111	111	010	0	000	000	000	111	100
0	000	111	111	111	011	1	000	010	110	010	010
0	000	111	111	111	100	0	110	101	000	000	000
0	000	111	111	111	101	0	000	101	001	100	100
0	000	111	111	111	110	0	000	001	000	000	000
0	000	111	111	111	111	0	000	111	111	011	101

Appendix C
Tape-to-Core Bootstrap

The tape-to-core bootstrap is used to lead the fallout or prompt effects load function from tape (for loading the system from tape) or the disc diagnostic routine (see UCRL-50892, Vol. 4, Part 1). This bootstrap can be loaded from the computer console through switches on the front panel. Procedures for doing this are outlined in the operator's manual (UCRL-50892, Vol. 2) and in Ref. 1.

Address (binary)						Program word					
0	000	111	111	011	101	1	000	010	101	000	011
0	000	111	111	011	110	0	000	100	010	101	000
0	000	111	111	011	111	0	000	001	000	000	100
0	000	111	111	100	000	0	000	000	000	000	000
0	000	111	111	100	001	0	000	100	010	000	001
0	000	111	111	100	010	0	000	100	010	100	001
0	000	111	111	100	011	0	000	100	100	100	110
0	000	111	111	100	100	0	000	001	000	001	000
0	000	111	111	100	101	0	000	111	111	101	001
0	000	111	111	100	110	0	110	101	000	000	000
0	000	111	111	100	111	0	000	101	001	100	100
0	000	111	111	101	000	0	000	101	001	000	010
0	000	111	111	101	001	1	000	001	010	000	001
0	000	111	111	101	010	0	000	111	111	011	101
0	000	111	111	101	011	0	000	001	000	000	000
0	000	111	111	101	100	0	000	111	111	101	001

Appendix D

Disc-to-Core Bootstrap for Fallout

This bootstrap is used to load the Fallout Load Function from disc (for loading the system from disc). This bootstrap can be loaded from the computer console through switches on the front panel. Procedures for doing this are outlined in the operators manual (UCRL-50892, Vol. 2) and in Ref. 2.

Address (binary)						Program word					
0	000	111	111	011	101	1	000	011	001	100	010
0	000	111	111	011	110	0	000	110	001	100	000
0	000	111	111	011	111	0	011	111	111	000	000
0	000	111	111	100	000	0	000	001	000	001	000
0	000	111	111	100	001	0	000	000	000	111	101
0	000	111	111	100	010	0	000	110	001	010	000
0	000	111	111	100	011	0	100	000	000	000	000
0	000	111	111	100	100	1	000	001	001	000	010
0	000	111	111	100	101	0	000	111	111	111	011
0	000	111	111	100	110	0	000	001	000	000	000
0	000	111	111	100	111	0	000	111	111	100	100
0	000	111	111	101	000	1	000	001	100	000	010
0	000	111	111	101	001	0	000	111	111	101	100
0	000	111	111	101	010	0	000	001	000	000	000
0	000	111	111	101	011	0	000	111	111	101	000
0	000	111	111	101	100	0	000	110	000	001	000
0	000	111	111	101	101	1	111	111	111	001	001
0	000	111	111	101	110	0	000	110	000	010	000
0	000	111	111	101	111	0	010	011	101	110	101
0	000	111	111	110	000	0	000	101	011	010	010
0	000	111	111	110	001	0	000	001	000	010	000
0	000	111	111	110	010	0	000	111	111	110	101
0	000	111	111	110	011	0	000	001	000	000	000
0	000	111	111	110	100	0	000	111	111	110	000
0	000	111	111	110	101	0	000	101	001	001	001
0	000	111	111	110	110	0	000	001	000	000	100
0	000	111	111	110	111	0	000	111	111	101	110
0	000	111	111	111	000	1	000	000	001	000	010
0	000	111	111	111	001	0	000	110	000	011	000
0	000	111	111	111	010	0	000	000	000	111	100
0	000	111	111	111	011	1	000	010	110	010	010
0	000	111	111	111	100	0	110	101	000	000	000
0	000	111	111	111	101	0	000	101	001	100	100
0	000	111	111	111	110	0	000	001	000	000	000
0	000	111	111	111	111	0	000	111	111	011	100

Appendix E

Input/Output Computer Words for Fallout

The appendix contains a list of the input/output words of the fallout program. See UCRL-50892, Vol. 4, Part 1 for a complete description of the input/output commands used to transfer these words to and from the computer.

INPUT WORDS (n)2 Interface

	Bit				
	0	N-			Joystick Direction, response on a SEN 022 Instruction (0=Active) (PANEL)
	1	S-			
	2	E-			
W	3	W-			
O	4	Vernier + (0=slow) (PANEL)			
R	5	0.3	1	3	(d) Rad Level Selector (one-out-of-nine code, continued on word 6) (0=Active) (PANEL)
D	6	1	3	10	
	7	3	10	30	
0	8	10	30	100	
	9	30	100	300	
	10	100	300	1K	
	11	-			Momentary Switches, response on a SEN 012 Instruction (1=Active) (PANEL)
	12	Enter Ground Zero			
	13	Resume			
	14	Halt			
	15	Start			

	Bit		
	0	LSB	(c) Activity Constant Index (1=Active) (Rear Panel)
	1		
	2		
	3	Mode (0=Mode I) (PANEL)	
W	4	LSB	(n) Decay Exponent Index (1=Active) (Rear Panel)
O	5		
R	6	0.185	Map Scale (one-out-of-eight code) (0=Active) (PANEL)
D	7	0.413	
	8	0.740	
	9	1.650	
1	10	3.391	
	11	7.563	
	12	–	
	13	–	
	14	–	
	15	(h) Ground/Air Burst (0=air) (WEDS)	

WORD 2	0	LSB+	Drum Memory Buffer (Controller) (1=Active)
	1		
	2		
	3		
	4		
	5		
	6		
	7		
	8		
	9		
	10		
	11		
	12		
	13		
	14		
	15		

	Bit			
WORD 3	0	LSB	BCD Character Least Significant	Time Period (PANEL) (1=Active)
	1			
	2			
	3		DECIMAL POSITION	
	4	LSB	BCD Character	
	5			
	6			
	7			
	8	LSB	BCD Character	
	9			
	10			
	11			
	12	2K	(a) Wind Band Dept (one-out-of-four code) (Console Wind Panel) (0=Active)	
	13	4K		
	14	5K		
	15	6.56K		

WORD 4

Bit		Field	Function
0	LSB	BCD Character Least Significant	Display Time Delay (Rear Panel) (1=Active)
1			
2			
3			
4	LSB	BCD Character	
5			
6			
7			
8	–		
9	LSB	(w) Yield Characteristic 6 bit shift code (WEDS)	
10			
11			
12			
13			
14			
15	– (not available)		

Bit Code:

Bit		1 TON	10 TONS	100 TONS	1,000	10,000	100,000	1,000,000
9	-	1	0	0	0	0	0	0
10	-	1	1	0	0	0	0	0
11	-	1	1	1	0	0	0	0
12	-	1	1	1	1	0	0	0
13	-	1	1	1	1	1	0	0
14	-	1	1	1	1	1	1	0

WORD 5

Bit		Field	Function
0	LSB	BCD Character Least Significant	(F) Fission Yield/Total Yield Ratio (FY/TY) (1=Active)
1			
2			
3			
4	LSB	BCD Character	
5			
6			
7			
8	LSB	BCD Character	
9			
10			
11			
12	LSB	(j) Particle Size Distribution Index (1=Active) (Rear Panel)	
13			
14			
15	– (not available)		

Word	Bit				
WORD 6	0				
	1				
	2				
	3				
	4				
	5				
	6				
	7				
	8				
	9				
	10				
	11				
	12	300	1K	3K	(d) Pad Level Selector (one-out-of-nine code continued on word 0) (PANEL) (0=Active)
	13	1K	3K	10K	
	14	10	300	3K	
	15	– (not available)			

Word	Bit	
WORD 7	0	
	1	
	2	
	3	
	4	
	5	
	6	
	7	
	8	
	9	
	10	
	11	
	12	LSB (Z_b) Height of Burst (HOB) Characteristic 3 bit shift code (WEDS)
	13	
	14	
	15	– (not available)

Bit					
12 -	1	0	0	0	Bit Code
13 -	1	1	0	0	
14 -	1	1	1	0	
	1	10	100	1,000	

INPUT WORDS (n)3 Interface

WORD 1	Bit			
	0	LSB	BCD Character Least Significant	Direction (θ) and speed (σ) of wind band groups 1,6,11,16
	1			
	2			
	3			
	4	LSB	BCD Character	
	5			
	6			
	7			
	8	LSB	BCD Character Most Significant	
	9'			
	10			
	11			
	12	–		
	13	–		
	14	–		
	15	Enable		

WORD 2	Bit			
	0	LSB	BCD Character Least Significant	Direction (θ) and speed (σ) of wind band groups 2,7,12,17
	1			
	2			
	3			
	4	LSB	BCD Character	
	5			
	6			
	7			
	8	LSB	BCD Character Most Significant	
	9			
	10			
	11			
	12	–		
	13	–		
	14	–		
	15	Enable		

WORD 3	0	LSB	BCD Character Least Significant	Direction (θ) and speed (σ) of wind band groups 3,8,13,18
	1			
	2			
	3			
	4	LSB	BCD Character	
	5			
	6			
	7			
	8		BCD Character Most Significant	
	9			
	10			
	11			
	12	–		
	13	–		
	14	–		
	15	Enable		

	Bit			
WORD 4	0	LSB	BCD Character Least Significant	Direction (θ) and speed (σ) of wind band groups 4,9,14,19
	1			
	2			
	3			
	4	LSB	BCD Character	
	5			
	6			
	7			
	8	LSB	BCD Character Most Significant	
	9			
	10			
	11			
	12	–		
	13	–		
	14	–		
	15	Enable		

Word	Bit			
WORD 5	0	LSB	BCD Character Least Significant	Direction (θ) and speed (σ) of wind band groups 5,10,15,20
	1			
	2			
	3			
	4	LSB	BCD Character	
	5			
	6			
	7			
	8	LSB	BCD Character Most Significant	
	9			
	10			
	11			
	12	–		
	13	–		
	14	–		
	15	Enable		

INPUT WORDS (n)4 Interface

Word	Bit		
WORD 0	0	BCD Character Least Significant	(W) Yield Characters (1 = Active)
	1		
	2		
	3		
	← DECIMAL POSITION		
	4	BCD Character	
	5		
	6		
	7		
	8	BCD Character Most Significant	
	9		
	10		
	11		
	12		
	13		
	14		
	15		

WORD	Bit		
W	0	BCD Character Least Significant	(Z₀) Height of Burst (HOB) Characters (1 = Active)
O	1		
R	2		
D	3		
	← DECIMAL POSITION		
1	4	BCD Character	
	5		
	6		
	7		
	8	BCD Character Most Significant	
	9		
	10		
	11		
	12		
	13		
	14		
	15		

INPUT WORDS (n)5 Interface

WORD	Bit		
W	0	PROMPT/FALLOUT	"1" = Prompt, "0" = Fallout
O	1		
R	2		
D	3		
	4		
	5		
	6		
3	7		
	8		
	9		
	10		
	11		
	12		
	13		
	14		
	15		

OUTPUT WORDS (n)2 Interface

	Bit			
WORD 0	0	Start	Lamps for Momentary Switches	
	1	Halt	Lamps for Momentary Switches	
	2	Resume	Lamps for Momentary Switches	
	3	Enter Ground Zero	Lamps for Momentary Switches	
	4			
	5			
	6			
	7	–	(Not available)	
	8	–	(Not available)	
	9	–	(Not available)	
	10	–	(Not available)	
	11	–	(Not available)	
	12	–	(Not available)	
	13	–	(Not available)	
	14	–	(Not available)	
	15	–	(Not available)	
WORD 1	0	Air Burst	Function A Error	Error Indicators (PANEL)
	1	Map Area Too Small	Function A Error	Error Indicators (PANEL)
	2	Air Burst	Function B Error	Error Indicators (PANEL)
	3	Yield Too Small	Function B Error	Error Indicators (PANEL)
	4	Wind Speed Too Great	Function B Error	Error Indicators (PANEL)
	5	HOB Adj. Factor too Small	Function B Error	Error Indicators (PANEL)
	6	Map Area too Small	Function B Error	Error Indicators (PANEL)
	7	Map Area too Large	Function B Error	Error Indicators (PANEL)
	8	Wind Direction	Input Error	Error Indicators (PANEL)
	9	Wind Speed	Input Error	Error Indicators (PANEL)
	10	Other	Input Error	Error Indicators (PANEL)
	11	Disc Program Field Error		Error Indicators (PANEL)
	12			
	13			
	14	–	(Not available)	
	15	–	(Not available)	

	Bit		
	0	LSB	Drum Memory Buffer (Controller)
	1		
W	2		
O	3		
R	4		
D	5		
	6		
2	7		
	8		
	9		
	10		
	11		
	12		
	13		
	14		
	15	MSB	
	0	Variable Disp., Keyhold, Readout Pt., Grd. Zero	Drum Display Buffer (Controller)
	1	Variable Display	
	2	Variable Display (MSB)	
W	3	–	(Not available)
O	4	–	
R	5	–	
D	6	–	
	7	–	
3	8	–	
	9	–	
	10	–	
	11	–	
	12	–	
	13	–	
	14	–	
	15	–	

Word	Bit		Field	
4	0	LSB		
	1			
	2			
	3			
	4			
	5			
	6			
	7		Drum Address Buffer (Controller)	
	8			
	9			
	10			
	11			
	12			
	13	MSB		
	14	–	(Not available)	
	15	–		
5	0	LSB		
	1		BCD Character Least Significant	
	2			
	3		←DECIMAL POSITION	
	4	LSB		
	5		BCD Character	
	6			Time Readout (Numerical Display)
	7			
	8	LSB		
	9		BCD Character Most Significant	
	10			
	11			
	12	–		
	13	–	Not available	
	14	–		
	15	–		

	Bit			
WORD 6	0	LSB	BCD Character Least Significant	Rads/Hour Readout (Numerical Display)
	1			
	2			
	3			
	4		BCD Character	
	5			
	6			
	7		← DECIMAL POSITION	
	8		BCD Character	
	9			
	10			
	11			
	12	LSB	BCD Character Characteristics	
	13			
	14			
	15			
WORD 7	0	LSB	BCD Character Least Significant	Accumulated Dose Readout (Numerical Display)
	1			
	2			
	3			
	4	LSB	BCD Character	
	5			
	6			
	7		← DECIMAL POSITION	
	8	LSB	BCD Character	
	9			
	10			
	11			
	12	LSB	BCD Character Characteristic	
	13			
	14			
	15			

Although a particular embodiment of the invention has been illustrated and described, modifications and changes will become apparent to those skilled in the art, and it is intended to cover in the appended claims all such modifications and changes as come within the spirit and scope of the invention.

I claim:

1. A system for computing and displaying prompt and delayed effect of an explosive detonation with respect to a geographical area comprising: a computer means; control means operatively connected to said computer means through control logic circuit means; a circle generator means for generating a prompt effects display; said control means being operatively connected to said circle generator means through circle logic circuit means; said computer means being connected to said circle logic circuit means so as to direct signals thereto and receive signals therefrom; said control means additionally being connected to said computer means through interface logic circuit means for directing at least a pair of operational mode control signals to said computer means; a numerical readout means operatively connected to receive desired output signals from said computer means; a map projector means operatively connected to said computer means for receiving therefrom image-scale data for display of a map background by said map projector means; a fallout projection means operatively connected to said computer means and controlled thereby for projecting a fallout pattern as determined by said computer means; a screen means; said prompt effects, map background and fallout pattern being superimposed on said screen means, whereby a time varying display which illustrates prompt effects and fallout patterns of an explosive detonation, which can be readily changed to illustrate delayed effects, is shown on a map surface.

2. The system defined in claim **1,** additionally including a disk memory means operatively connected to said computer means to receive therefrom and direct thereto information signals.

3. The system defined in claim **1,** additionally including mirror means positioned between said screen means and each of said circle generator means, map projector means, and fallout projection means to assure proper superimposition on said screen means of said prompt effects, map background and fallout pattern.

4. The system defined in claim **1,** wherein said computer means is a digital computer.

5. The system defined in claim **1,** wherein said pair of operational mode control signals direct said computer means to display through said projection cathode ray tube means a previously predicted fallout pattern of a detonation and a fallout pattern as determined by current wind, gravity and pertinent physical characteristics of the detonation.

6. The system defined in claim **1,** wherein said fallout projection means is a projection cathode ray tube.

7. The system defined in claim **1,** wherein said control means includes numerous actuators, selectors, push-button and switch means positioned on a control panel; and wherein said numerical readout means and said screen means are positioned adjacent said control panel; the map background, fallout pattern, and prompt effects shown as concentric circles being superimposed on one side of said screen means in such a manner that same are viewed from the other side thereof.

* * * * *